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Effects of Civil Tiltrotor Service in the Northeast Corridor On En Route Airspace Loads

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U.S. Department of Transportation

Federal Aviation Administration

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of Transportation

**Federal Aviation
Administration**

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Dear Colleague:

Enclosed is a copy of **FAA/AOR-100/94/008, Effects of Civil Tiltrotor Service in the Northeast Corridor on En Route Airspace Loads.** This is one in a set of documents intended to inform senior decision makers and other interested parties of the potential effects of civil tiltrotor (CTR) service on National Airspace System performance.

A tiltrotor combines the vertical take-off and landing capabilities of a helicopter with the cruise speeds and altitudes associated with a high-performance conventional turboprop aircraft. To date, tiltrotor development has progressed furthest in the military. However, tiltrotor capabilities make them attractive for civilian use.

These aircraft operate using considerably less ground space than airplanes. Consequently, CTR could provide greater flexibility by enabling passengers to take off and land closer to their actual origins and destinations rather than limiting them to conventional airport locations. CTR may be able to operate without interfering with airplane flows, even in the airspace around congested metropolitan airports.

In the en route airspace, tiltrotor aircraft are expected to operate like turboprops. Some in the aviation community have questioned whether the introduction of civil tiltrotor will cause en route congestion. This analysis emphatically shows that this will not be the case. Even under today's air traffic system and it's many constraints, tiltrotor operations will not overload en route sectors. In a future air traffic system with an advanced automation system and free flight operations, this will certainly be the case. Thus CTR shows great promise for increasing airport capacity and reducing congestion and delays.

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16. Abstract

This report documents an analysis of the effects of the introduction of civil tiltrotor (CTR) service on en route airspace loads. The analysis is intended as one in a set of analyses designed to provide information to senior decision makers and other interested parties on the potential effects of CTR service on National Airspace System performance. The analysis uses a demand scenario that addresses the introduction of CTR services into the Northeast Corridor of the United States using several simplifying assumptions.

This report also includes an update on the previously published report "Civil Tiltrotor Northeast Corridor Delay Analysis (Based on the Demand Scenario Described in *Civil Tiltrotor Missions and Applications Phase II: The Commercial Passenger Market*)", FAA/AOR-100/93/013.

(This document is based on briefing materials developed to report on the results of this analysis. In the interest of saving money, these briefing materials have not been expanded to the full text more typical of technical reports. Instead, this document contains copies of the briefing slides and the associated briefing text.)

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EXECUTIVE SUMMARY

This report describes the En Route Airspace Load Analysis. It assesses the effects of Northeast Corridor civil tiltrotor aircraft service on en route airspace loads. The National Airspace System (NAS) Performance Analysis Capability Simulation Modeling System was used to track en route airspace load rates throughout a simulated busy traffic day. Four demand scenarios were analyzed with different civil tiltrotor (CTR) and fixed-wing demand profiles in order to provide a range of levels of traffic in the en route airspace. The analysis was conducted using a busy traffic day for both year 1990 and year 2000 timeframes for all four demand scenarios, giving eight scenarios in total.

Of the more than 700 en route airspace sectors in the NAS, we analyzed the 112 northeastern sectors that had more than two flights added or removed because of the simulated CTR service. There are several sectors with potential overload problems appearing in the year 2000 results, but the severity of the overload is low. Overall, we conclude that no major overload problems are foreseen for any of these sectors except a sector for which the problem is not caused by CTRs.

Subject to the assumptions and caveats included in this report, we conclude that the introduction of civil tiltrotor service in the northeast corridor will have no significant impact on en route airspace loads.

At the beginning of the main document is a brief note which provides updated information on an earlier companion analysis.

UPDATE ON "PHASE II DELAY ANALYSIS"

This note provides updated information of a previous analysis and can stand alone and be considered separate from the main report's review of the En Route Airspace Load Analysis.

In November 1993, The MITRE Corporation's Center for Advanced Aviation System Development (CAASD) published a report titled "Civil Tiltrotor Northeast Corridor Delay Analysis (Based on the Demand Scenario Described in *Civil Tiltrotor Missions and Applications Phase II: The Commercial Passenger Market*)."[1] As its title suggests, the Phase II Delay Analysis was based on the complete set of flights identified in the 1991 NASA/FAA study titled "Civil Tiltrotor Missions and Applications Phase II: The Commercial Passenger Market,"[2] although it included a summary of a sensitivity analysis conducted by the FAA Technical Center which examined reduced market capture rates. As stated in the Phase II Delay Analysis report, its results were intended to establish a baseline of maximum achievable airport delay reduction benefits from Northeast Corridor CTR service. Because of some criticism of the market capture assumptions (i.e., that they were too optimistic), this note presents an alternative scenario based on a reduced CTR market capture rather than the more optimistic baseline of delay reductions presented earlier.

In the Phase II Delay Analysis, demand scenarios were analyzed in which different CTR market capture rates provided a range of levels of traffic reduction at Northeast Corridor airports. The National Airspace System Performance Analysis Capability (NASPAC) simulation modeling system (SMS) was used to simulate airport operations. Results were provided in the form of estimated annual delay reductions for year 1990 and year 2000 timeframes based on weather-annualized scenarios. Results were categorized as follows: the seven main Northeast Corridor airports, their feeder airports, and all other airports. The key conclusions in the Phase II Delay Analysis report were that significant airport delay reductions can occur if fixed-wing aircraft traffic load is decreased due to the introduction of CTR service. Also, a substantial portion of the delay reduction would be realized even if the market capture rate is significantly reduced from the full Phase II Market Study rates.

In recent presentations summarizing the delay reduction results, a reduced market capture rate has been assumed to reflect an alternative market potential for CTRs. This note summarizes how the key results in the Phase II Delay Analysis report would change based on assuming that 50 percent of the original market capture is realized. Results for the 25 percent, 75 percent, and 100 percent market capture rate cases can then be viewed as sensitivity analysis around the "standard" case which uses rates based on 50 percent of the CTR removal flights from the Phase II Market Study.

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1 Hereinafter referred to as the "Phase II Delay Analysis" report.

2 The study is hereinafter referred to as the "Phase II Market Study."

An updated market analysis by the Volpe National Transportation Systems Center (VNTSC) is currently underway. It includes networks of CTRs operating in four geographical regions of the United Stated rather than the one network in the Northeast Corridor included in the NASA/FAA study. When the VNTSC results are obtained, a new airport delay analysis will be undertaken based on the new estimates of CTR market potential. Until this new analysis is completed, the following presentation is the current best estimate of the potential airport delay reduction benefits due to the introduction of CTR service (in the Northeast Corridor).

In the interest of brevity, only year 2000 results are included in this preface. The results include two metrics of airport delay. Technical delay is the delay incurred by an aircraft while waiting to use a busy air traffic control system resource (e.g., airport runways). Effective arrival delay is the difference between the time an aircraft arrives at its gate in the simulation and the aircraft's scheduled arrival time. This measures passenger lateness, and includes the ripple effect caused by aircraft lateness on one leg of an itinerary which may affect the arrival time on later legs. It is highly dependent on airline scheduling practices.

The sensitivity analysis, completed by the FAA Technical Center, assessed the sensitivity of the Phase II Delay Analysis results to various alternative market capture rates. The combined aggregate results of the two studies are included in Figure P-1. The Phase II Delay Analysis identified two points on these curves—0 percent market capture (baseline demand) and 100 percent. The sensitivity analysis determined three more points on the curves: 25 percent, 50 percent (the new "standard" for CTR market potential), and 75 percent of the Phase II market capture rate. The key finding was that a substantial portion of the delay savings are

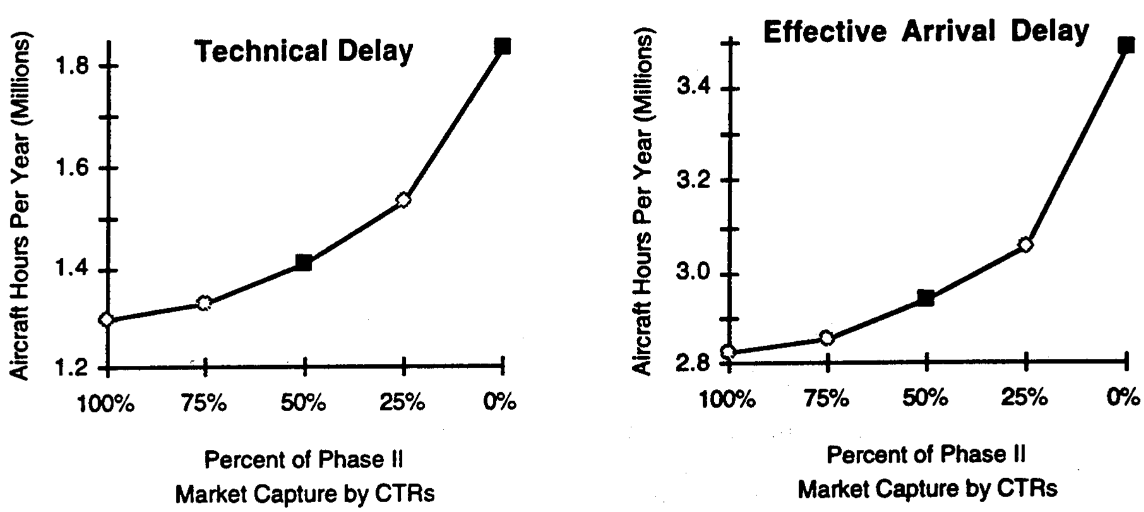

Figure P-1. Sensitivity of Delay Reductions to Market Capture Rate realized even if the market capture rate is assumed to be much lower than originally estimated. As a result, the overall conclusions of the original Phase II Delay Analysis report are relatively unaffected by the new standard for CTR market potential. Note that these curves show the delay reductions on a nationwide basis and that most of the delay reductions occur at the seven Northeast Corridor airports, where the benefit is significant, as shown in Figure P-2.

Figure P-2 shows the year 2000 delay results for the baseline and CTR (fixed-wing removal) scenarios in terms of the two metrics used in the original study. Unlike the original report, these charts use the 50 percent rate as the standard for CTR market potential with the values for the 100 percent rate shown with a dashed line. As can be seen in Figure P-2, the reduction in delay from the baseline demand scenario to the removal scenario is smaller using the 50 percent removal rate, but not dramatically so.

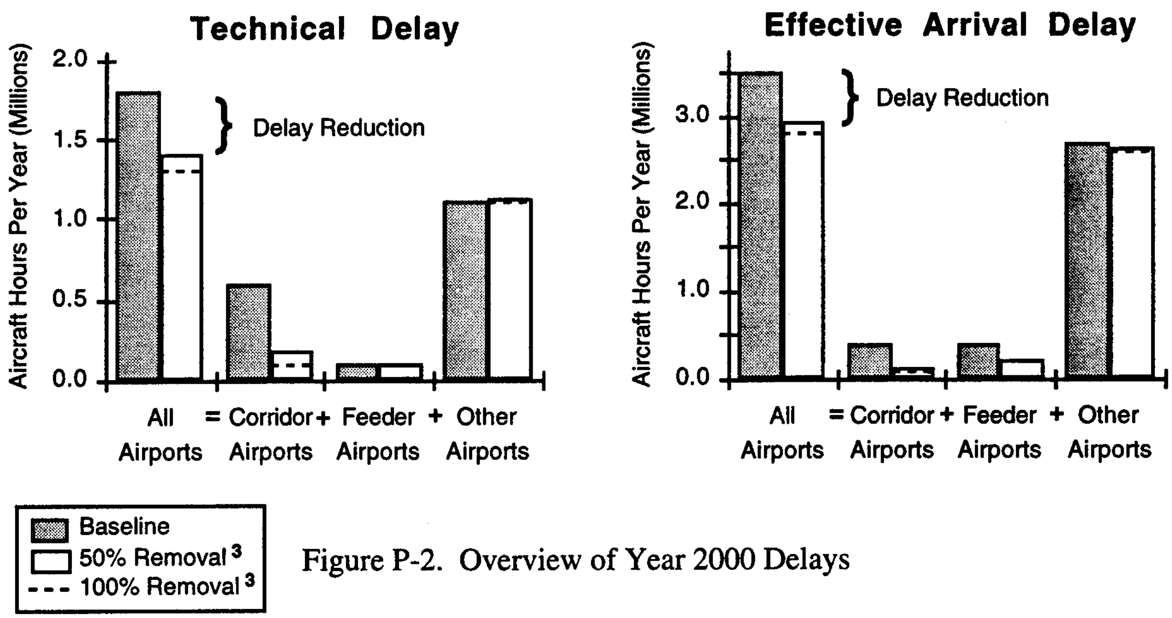

Figure P-2. Overview of Year 2000 Delays

There were several key assumptions made in the Phase II Delay Analysis. First, we assumed that CTR service would capture part of the demand for fixed-wing aircraft travel, replacing that demand, and thereby reducing the number of fixed-wing flights. As a result, demand on airport capacity would be reduced and delays would be reduced. In practice, there would likely be some refilling of airport arrival and departure slots freed up by the elimination of fixed-wing flights ("backfilling"). This would have the effect of reducing the delay reduction benefits. On the other hand, the benefit due to the increase in throughput, without a corresponding increase

3 "X% Removal" means CTR market capture is assumed to be X percent of that used in the Phase II Delay Analysis (i.e., X percent of Phase II Market Study rates).

in airport load (and accompanying delays), would increase. The actual benefits would likely be some combination of throughput increase and delay reductions. Determining what proportion to assume for each part is a judgment which we leave to others.

In the "50 Percent Removal" scenario, daily operations at the seven Northeast Corridor airports were reduced by about 18 percent, or about 1,100 operations, from the approximately 6,150 operations in the baseline scenario in the year 1990. To the extent that backfilling would occur instead of delay reductions, the introduction of CTR service would free up about 1,100 additional fixed-wing operations at these airports while maintaining the same level of airport delays as would occur without CTR service. Thus, the potential throughput increase would be substantial if it were to become the principal benefit instead of delay reduction. Alternatively, in terms of additional passengers carried, this translates into maintaining the current load of passengers with fixed-wing aircraft while handling well over 25,000 additional passengers per day with CTRs (this estimate is derived from the year 1990 market capture data used in the En Route Airspace Load Analysis).

The other key assumption made for the Phase II Delay Analysis is that CTRs would not interfere with fixed-wing aircraft in the en route and terminal area airspaces. The En Route Airspace Load Analysis, summarized in this document, tests the validity of this assumption in en route airspace. The reasonableness of the non-interference assumption in the terminal area environment is being investigated by an analysis currently underway in the System Analysis Division of the FAA's Operations Research Service (AOR).

The analysis to be performed by CAASD in 1994–1995 will evaluate the regional and national impact of CTR service in four areas: the Northeast Corridor, the Chicago circle, the Dallas-Fort Worth area, and the California-Arizona corridor. These analyses will consider three scenarios for each area: a baseline (i.e., no CTR) and two others. Results will be generated for a current year and a future year (2000 or 2005). Market capture data for these analyses will be provided by VNTSC as results from their 1993–1994 economic evaluation of the market potential for CTR aircraft.

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Introduction

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This report documents the "Effects of Civil Tiltrotor Service in the Northeast Corridor on En Route Airspace Loads" analysis performed by The MITRE Corporation's Center for Advanced Aviation System Development (CAASD). This analysis is referred to hereinafter as the "En Route Airspace Load Analysis."

A tiltrotor aircraft combines the vertical takeoff and landing capabilities of a helicopter with the cruise speeds and altitudes associated with a high-performance conventional turboprop aircraft. The vertical capabilities of tiltrotor aircraft could make them attractive for civilian use for several reasons. These vertical capabilities allow tiltrotor aircraft to operate using considerably less ground space than conventional fixed-wing aircraft. This could provide more scheduling flexibility to passengers by allowing them to take off and land closer to their actual origins and destinations, rather than limiting them to conventional airport locations. If tiltrotor aircraft can be operated in a non-interfering manner, they could be used to supplement limited airport capacity and relieve congestion and delays at busy airports in metropolitan areas.

Purpose of Analysis

- Provide quantitative analysis in support of decisions regarding investment in civil tiltrotor (CTR) technology and infrastructure
  - Conduct one of several analyses that, when taken together, provide insight into effects of Northeast Corridor CTR service on air traffic control system
  - This en route airspace load analysis
    - Assesses effects of Northeast Corridor CTR service on en route airspace loads
    - Tests for and identifies potential problem areas that may require further study

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The En Route Airspace Load Analysis is one in a series of analyses in support of decisions regarding potential investment in civil tiltrotor (CTR) technology and the infrastructure required to support that technology and incorporate it into the national transportation system. It is designed to provide information to senior decision makers and other interested parties on the potential effects of CTR service on National Airspace System performance.

The implicit assumption throughout this analysis is that sector loads are a reasonable approximation of potential en route airspace design and controller workload problems. Since controller overloading problems could translate into reduced safety this is a potential concern for the introduction of a new aircraft technology which could increase the number of aircraft using the system.

The En Route Airspace Load Analysis tests for potential sector overload problems in order to identify potential problem areas that would require further study. It thus examines the ability of CTRs to operate in a non-interfering manner with fixed-wing aircraft in en route airspace. Other analyses have been specifically designed to address other aspects of CTR effects.

Background

- This analysis builds on assumptions and market capture results of the 1991 NASA/FAA Phase II Market Study*
- Many of the assumptions, data, and methodology used in this analysis are based on 1993 MITRE/FAA Phase II Delay Analysis.* That study represented the first in a set of related analyses designed to address various questions about effects of introducing CTR service into the National Airspace System (NAS)

* See References section for complete title.

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The En Route Airspace Load Analysis assesses the effects of Northeast Corridor civil tiltrotor aircraft service on en route airspace loads. It builds on the market study entitled "Civil Tiltrotor Missions and Applications Phase II: The Commercial Passenger Market" (by Boeing for the National Aeronautics and Space Administration [NASA] and the Federal Aviation Administration [FAA], 1991), which is referred to hereinafter as the "Phase II Market Study." That study assessed aircraft characteristics and the potential market for CTR aircraft.

The En Route Airspace Load Analysis is a continuation of a series of analyses that began with the MITRE/FAA analysis documented in "Civil Tiltrotor Northeast Corridor Delay Analysis (Based on the Demand Scenario Described in *Civil Tiltrotor Missions and Applications Phase II: The Commercial Passenger Market*)," The MITRE Corporation, 1993, which is hereinafter referred to as the "Phase II Delay Analysis." The En Route Airspace Load Analysis uses many of the same assumptions, data, and methodology in that analysis. The Phase II Delay Analysis report should be reviewed for more detail.

Key Analysis Assumptions

- Northeast Corridor CTR service will capture part of the fixed-wing aircraft market, thereby reducing demand for fixed-wing aircraft. Represented in analysis by:
  - Removing fixed-wing flights identified in Phase II Market Study and introducing identified replacement CTR flights (on seat-by-seat basis)
- No new fixed-wing flights will refill slots made available by reduction in fixed-wing demand due to new CTR service (i.e., no *backfilling* of *removed* flights due to additional demand in response to newly available capacity)
- CTRs will not compete with fixed-wing aircraft for terminal area ATC resources (validity explored by another analysis)
- 1991 Monitor Alert Threshold (MAT) used for sector capacity

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The most critical of the analysis assumptions are summarized here. The appendix contains a listing of more assumptions.

A main conclusion of the Phase II Market Study was that Northeast Corridor CTR service would capture part of the Northeast Corridor conventional, fixed-wing aircraft market, thus reducing the demand for Northeast Corridor fixed-wing aircraft service. Supporting data from the Phase II Market Study included lists of specific fixed-wing flights that were identified as candidates for CTR replacement if service was in place in the year 1990. The flights in these lists were removed in the En Route Airspace Load Analysis to represent the reduced fixed-wing demand assumed to be associated with the introduction of Northeast Corridor CTR service. All eliminated fixed-wing flights were assumed to be replaced, or "captured," by CTR service.

It is assumed that no new fixed-wing flights will refill airport departure and arrival slots made available by this reduction in fixed-wing demand (this assumption is relaxed in one alternative demand scenario as a sensitivity analysis). Replacement CTR flights are introduced into the system in place of the removed flights by adding CTR flights on a seat-by-seat basis, maintaining the same passenger capacity as the original schedule. If new fixed-wing flights were to appear through backfilling, airport delay reductions would be reduced but throughput would increase.

Note that there is no attempt to model ATC or airline response to sector overload problems that may arise in the course of the simulated scenarios. This analysis seeks to ***identify*** such problems, not resolve them. As a result, some results could appear unrealistic because sector capacities are not enforced in the simulations.

The sector load metrics used in this analysis are compared to sector capacity. For this analysis, the 1991 Monitor Alert Thresholds (MATs) are used for capacity. The source year (1991) for MATs is the same as the source year of sector geometries. MATs are the best available values, but they should be viewed as only approximate measures of capacity. They are not intended to be hard-and-fast limits on capacity, but rather are only general indicators of overload levels.

Quoting from the "Enhanced Traffic Management System (ETMS) Functional Description," Version 4.2, January 1992, by VNTSC, page 8-5:

> "An alert threshold is defined as the level of traffic demand required at an element for it to be brought to the attention of a traffic management specialist. The alert thresholds are sometimes referred to as the capacities of the elements, but are not capacities in the classical sense. ... For sectors, the ETMS generates ... [an] alert only if the ... demand exceeds the threshold."

Thus, an alert is only an indication of an existing or predicted problem which merits investigation by a traffic management specialist to determine if intervention (such as assignment of delays or rerouting) is necessary.

Terms and Concepts

- **"Baseline" demand scenario uses complete set of fixed-wing traffic and no CTRs**
- **Alternative demand scenario ("50% Replacement") has CTRs replacing fixed-wing flights at a rate of 50 percent of that identified in Phase II Market Study. Because that study's results may be overly optimistic, standard replacement scenario assumes lower rate**
- **Two other demand scenarios analyzed to test results' sensitivity to capture rate (results shown in Appendix)**
  - **Higher market capture rate of "100% Replacement" uses complete market capture rates from Phase II Market Study**
  - **"50% Replacement with Backfill" scenario assumes CTR demand equal to 50% Replacement level with *no* corresponding reduction in fixed-wing demand**

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Four demand scenarios were analyzed in which different CTR and fixed-wing demand profiles provide a range of levels of traffic in the en route airspace.

- The "Baseline" demand scenario uses a complete set of fixed-wing traffic (i.e., no flights are removed) and no CTRs.

- The standard alternative scenario is referred to in this report as the "50 Percent Replacement" case. For this scenario, CTRs replace fixed-wing flights at a market capture rate equal to 50 percent of that identified in the Phase II Market Study. That study's results may be overly optimistic in its market capture rates; thus, 50 percent of that rate is used in this analysis.

As a sensitivity analysis of the potential CTR demand rate and the effect on fixed-wing traffic, two other demand scenarios were analyzed.

- A higher market capture rate, the "100 Percent Replacement" case, uses the complete list of captured flights from the Phase II Delay Analysis (these flights were derived from the results of the Phase II Market Study). This was presented in the Phase II Delay Analysis as the standard alternative scenario (referred to there as the "with CTR" or "Removal" scenario because the presence of CTR service would result in a reduction of fixed-wing traffic which was represented by removing those flights from the demand). To the extent that the Phase II Market Study's CTR market capture rate results are considered overly optimistic, this "100 Percent Replacement" case is overly conservative (it may exaggerate overload problems) with respect to the extremes of CTR impact on sector load.

- As a test of the assumption that no refilling of freed up fixed-wing slots would occur, the "50 Percent Replacement with Backfill" scenario assumes that the standard (50 percent rate) number of CTR flights are added, but that there is no reduction in fixed-wing traffic. This would result if all freed slots have been refilled by new demand. For example, such refilling of slots could be part of air carrier reaction to the introduction of CTR service at slot-controlled airports.

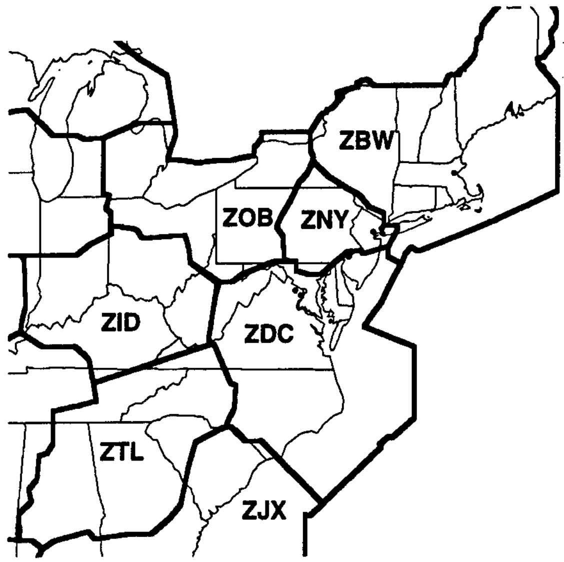
  Fixed-wing traffic equals that in the baseline scenario and CTR traffic matches that in the 50 Percent Replacement scenario. This is an ***extreme*** assumption regarding the degree of backfilling of fixed-wing slots. This is appropriate only because this assumption is part of a sensitivity analysis and is meant to explore the ***bounds*** of the likely scenario, not necessarily the most likely outcome itself.

Terms and Concepts (Concluded)

Map of Northeast Corridor Airspace

Center	Number of Sectors	Sectors w/ CTR Activity*
ZBW	30	28
ZDC	44	30
ZID	36	2
ZJX	38	0
ZNY	29	25
ZOB	42	25
ZTL	45	2
Total	264	112

* Number of sectors with more than two CTR replacement flights or fixed-wing removal flights per day



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The "Northeast Corridor" is defined in this report by the en route airspace sectors through which fixed-wing aircraft or CTRs fly between airport pairs which were documented in the Phase II Delay Analysis report. This traffic network consists of "corridor" airports (7) and vertiports (12) in Boston, New York, Philadelphia, and Washington, DC, plus "feeder" airports with collocated vertiports (69). Feeder airports are located within 500 miles of a corridor airport and currently have flights that directly connect to corridor airports.

Northeast Corridor traffic flew through sectors in the airspace of seven Air Route Traffic Control Centers (ARTCC, or "center" airspace). Note that the center names are included in the glossary. We restricted our attention to examining only the 112 sectors within those centers which had more than two fixed-wing flights removed or CTR flights added in the 50 Percent Replacement demand scenario for the year 1990 analysis. This criterion was selected to eliminate from consideration any sectors for which the introduction of CTR service was judged to clearly have a negligible effect. Although some sectors which have more than two flights might also be negligibly affected by CTR service, a small number of flights was chosen for the criterion as a conservative cutoff in order to avoid eliminating possibly relevant sectors.

The term "sector load" refers to the number of aircraft of any type within a sector's boundaries at any particular point in time or duration of time. If a snapshot count of sector load is intended, the term "instantaneous aircraft count" is used instead.

Methodology

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Overview of Methodology

- National Airspace System Performance Analysis Capability (NASPAC) Simulation Modeling System (SMS) used to track en route airspace load rates (instantaneous aircraft counts in all sectors) throughout simulated busy day
- Analysis of results:
  - Focus: Compare results between baseline and replacement/backfill scenarios, to estimate changes in sector loads due to different number of flights with presence of new CTR service
  - 112 sectors in Northeast Corridor had more than two fixed-wing removal flights or CTR replacement flights pass through them (out of more than 700 sectors in National Airspace System); only results from those sectors were analyzed

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The En Route Airspace Load Analysis used the National Airspace System Performance Analysis Capability (NASPAC) Simulation Modeling System (SMS) to track instantaneous aircraft counts in all en route airspace sectors throughout a simulated busy traffic day. Traffic is based on all visual meteorological conditions (VMC) in order to maximize the total en route load and maintain the demand peaks in actual schedules as the flights in the SMS advance through the day.

Four demand scenarios, as defined earlier, were examined for two timeframes, 1990 and 2000. The year 1990 is the timeframe of the supporting data from the Phase II Market Study and provides a foundation to test the methodology. The year 2000 (according to the Phase II Market Study) is the target year for introducing Northeast Corridor CTR service. Airport capacities and most other model data match the data discussed in the Phase II Delay Analysis report. CTR aircraft performance characteristics were coordinated with Boeing, and sector airspace geometries are based on 1991 data.

During the SMS output analysis phase, the results from the baseline and alternative replacement/backfill scenarios were compared in order to estimate potential changes in sector loads due to the different number of flights, flight paths, and schedule differences with the presence of new CTR service. Of the more than 700 sectors in the NAS, 112 sectors in the Northeast Corridor were analyzed for changes. All other sectors had two or fewer fixed-wing flights removed or CTR replacement flights added in the 50 Percent Replacement scenario for the year 1990.

Metrics of Interest*

- **Analysis Objective: Identify sectors with potential overload problems due to CTR and estimate magnitude of problem**
- **No single metric adequately measures airspace load, so several metrics were used to present overall picture. Metrics relate to number of aircraft in sector (peak and/or sustained load) during busy periods in simulated day**
  - **Average sector load during peak quarter-hour period**
  - **Minutes per day in which sector load exceeds 1991 MAT**
  - **MaxIAC**

*** See Appendix for a more detailed discussion.**

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The goal of this analysis is to identify sectors with potential overload problems and to estimate the magnitude of the problem. (Are the overloads small enough so that they can be handled by routine operational adjustments, or are they major problems?) There is no single measure of sector load which adequately supports this identification and estimation problem, so several metrics were computed and analyzed in order to present an overall picture. All of these metrics relate to counts of the number of aircraft in a sector during busy periods of the simulated day. Both peak and sustained peak load were of interest.

The sector load metrics discussed below are compared to sector capacity. As discussed on page 5, for this analysis, the 1991 MATs are used for capacity. MATs are the best available values, but they should be viewed as only approximate measures of capacity. They are not intended to be hard-and-fast limits on capacity, but rather are only general indicators of overload levels, as discussed earlier. It is also important to note that for the analysis performed for the year 2000 timeframe, there is a nine year discrepancy between the assumed level of the demand and any technical or procedural improvements which may improve the ability to handle more traffic.

A commonly used metric of sector load is the maximum instantaneous aircraft count (MaxIAC). In this analysis, MaxIAC measures the highest possible load that occurs during a simulated day, regardless of the duration of the incident. We have included summaries of this metric, but do not feel that it provides a very robust measure of the magnitude of overload problems. It should be recognized that geographical sector boundaries do not precisely match the locations of controller responsibility on a moment-by-moment basis (handoffs do not always occur between controllers at the precise boundary between their sectors). In addition, aircraft are typically reassigned new routes (with vectoring and speed control) in practice to alleviate momentary overload problems, but the NASPAC SMS does not model such actions. Thus, instantaneous aircraft counts which appear in the NASPAC SMS results may not precisely reflect actual instantaneous sector loads which would occur in the NAS under similar conditions.

The MaxIAC may best be used as a filtering metric. If a sector's load never exceeds its capacity (i.e., its MaxIAC does not exceed its MAT), then in this analysis it is assumed that there is never an overload problem and that sector need not be analyzed further. Per the discussion on page 5, using MaxIAC relative to MAT is a robust filter which likely would capture many sectors that would not actually pose a potential overload problem.

In order to balance out the variability of instantaneous aircraft counts, a measure over a period well beyond several seconds was deemed more meaningful than a measure over very short durations. The primary metric used for this analysis is the average load during the peak quarter-hour period. This duration was chosen after consultation with several air traffic controllers, in order to provide an estimate of a sustainable overload problem. The 15-minute duration is also consistent with the time periods used for ETMS monitor alerts. This metric provides a measure of the magnitude of the worst period of overload problems sustained for a quarter-hour duration. The calculation was made by taking the average sector load for every 15-minute interval throughout the simulated day (not just those intervals falling at 0, 15, 30, or 45 minutes after the hour), and taking the maximum.

Another estimate of sustained load which is reported here is the number of minutes per simulated day in which the sector load exceeds capacity (i.e., MAT). The total need not be in continuous time, and includes the sum of any seconds of overload added up throughout the day. It does not account for how high above the capacity the load is, but rather just the total duration of the overload period. This metric is intended to provide a better measure of the total duration of potential overload problems without concern as to the time of day in which they occur.

It is important when reviewing the results graphs not to emphasize any one specific case of overload, namely for one particular metric or one particular scenario. Because of randomness in any simulation (and the limited number of runs used with this analysis), there is a small but perceptible variability of the metrics which may overstate or understate the significance of load problems for any particular instance. General patterns supported by several occurrences of problems should be sought instead.

Results

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Overview of Results

- CTR traffic did not cause or seriously aggravate an overload problem in any Northeast Corridor sector for 50% Replacement scenario. As a sensitivity analysis, 100% Replacement and 50% Replacement with Backfill scenarios (results shown in Appendix) were tested with results that also support that conclusion.
- Two timeframes for each scenario: 1990 and 2000
- Graphs included in this document summarize results for the nine sectors which satisfied at least one of the three criteria shown on the following page
- Also shown on page 17 (to provide sense of variability of sector load) is a chart of load profile (graph of one-minute average loads) throughout day for a selected sector

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This document's charts summarize the level of the three metrics for the baseline and three alternative replacement/backfill scenarios. Each chart shows the baseline with one of the three alternatives for either the year 1990 or 2000 timeframe. Thus, there are two timeframes, three metrics, and three scenario comparisons, for a total of 18 charts in all. The six charts for the baseline versus the 50 percent replacement scenario are included in the main document and the other twelve charts are included at the end of the appendix.

The nine sectors which appeared to be potential problems in any of the four scenarios are shown in each graph. These sectors were identified based on criteria summarized on the following page; the results are shown in more detail in the Summary and Conclusions section.

A chart on page 17 shows one-minute average loads throughout the day for a selected sector. The purpose is just to provide a sense of the variability of a sector's load throughout the day—it is not part of the quantitative analysis simulation results, but rather is a sample of an intermediate result from which final results were derived.

Results Overview (Continued)

- **Only a small number of affected sectors exceeded the following load levels at least once during the day**
  - **Peak quarter-hour average load exceeds MAT**
  - **Sector load exceeds MAT for more than 10 minutes per day**
  - **MaxIAC exceeds 130 percent of MAT**

	1/4-Hr Load > MAT		Load > MAT for > 10 min/day		MaxIAC > 130% MAT	
	1990	2000	1990	2000	1990	2000
Baseline	1	2	1	1	1	2
50% Replacement	1	4	1	2	1	4
100% Replacement	3	6	3	7	3	6
50% with Backfill	1	4	1	4	1	4

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Regardless of which scenario is examined, for which timeframe, or which metric, only nine sectors appear to have a potential overload problem. Up to seven appear for a specific year/scenario/metric case, as detailed on pages 29–30 and summarized above. The nine sectors are shown below and are described more on the following page. These sectors are included in all results charts in this document.

ZBW019	ZDC059	ZNY039
ZDC027	ZNY010	ZNY055
ZDC032	ZNY036	ZOB051

The details of which sectors appear for each metric/scenario combination are included in the Summary and Conclusions section. The sectors were identified based on the following criteria:

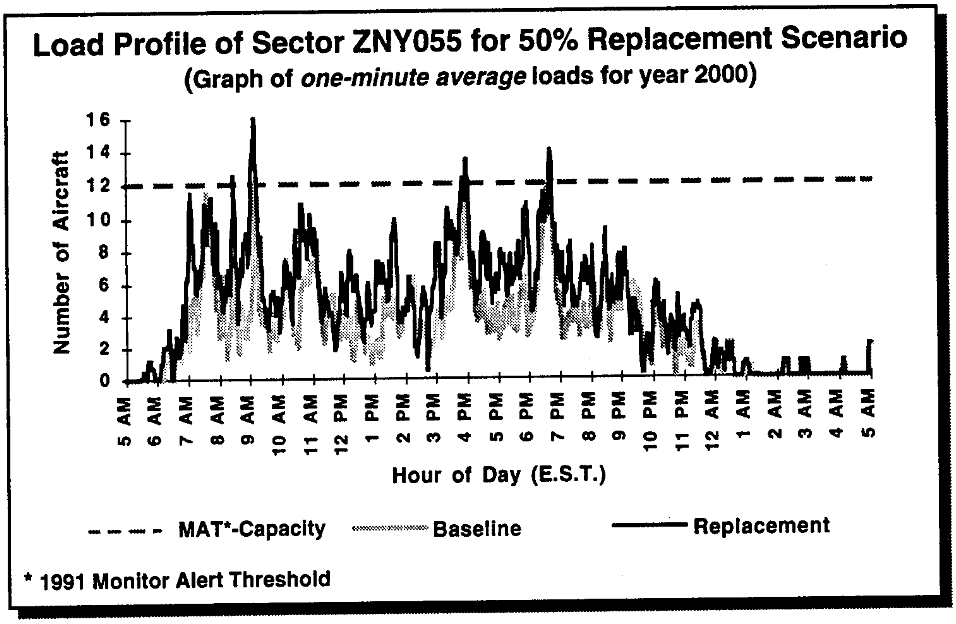
- The peak quarter-hour load exceeds the 1991 MAT
- The sector load exceeds the 1991 MAT for more than ten minutes per day. The time need not necessarily be a single, continuous time interval, but is composed of the sum of the durations of all periods when the instantaneous aircraft count exceeds the MAT.
- The MaxIAC exceeds the 1991 MAT by more than 30 percent.

For general information, note that the nine sectors included in the summary charts cover the following altitude ranges (in feet above sea level):

Sector	Name	Minimum	Maximum	Note
ZBW019	IGN	18,000	Unlimited	High altitude sector
ZDC027	LIBERTY	10,000	23,000	Low altitude sector
ZDC032	GORDONSVILLE	21,000	Unlimited	High altitude sector
ZDC059	SEA ISLE	18,000	Unlimited	High altitude sector
ZNY010	HARH	22,000	None	High altitude sector
ZNY036	SAX	5,000	24,000	Low altitude sector
ZNY039	PARKE	14,000	29,000	Low to high altitude sector
ZNY055	ARD	13,500	29,000	Low to high altitude sector
ZOB051	CIP	1,500 AGL*	24,000	Low altitude sector

* AGL = Above Ground Level

Results Overview (Concluded)



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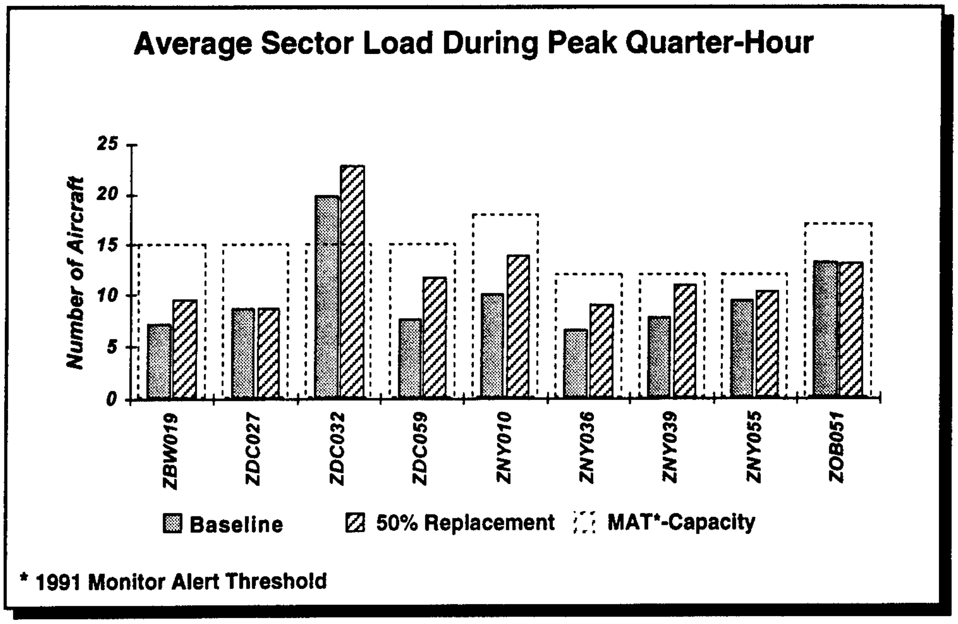
The purpose of this graph is to give a general picture of the ***pattern*** of the en route airspace load throughout the day as produced by the NASPAC SMS. Data of this sort were then processed to compute the various metrics, as discussed elsewhere in this document. This graph is intended to provide an indication of the very erratic pattern of airspace loads, including the existence of multiple peaks, the sustainability (or lack of it) of the load peaks, and the differences between the baseline and replacement scenarios.

Baseline vs. 50% Replacement: Year 1990 Results



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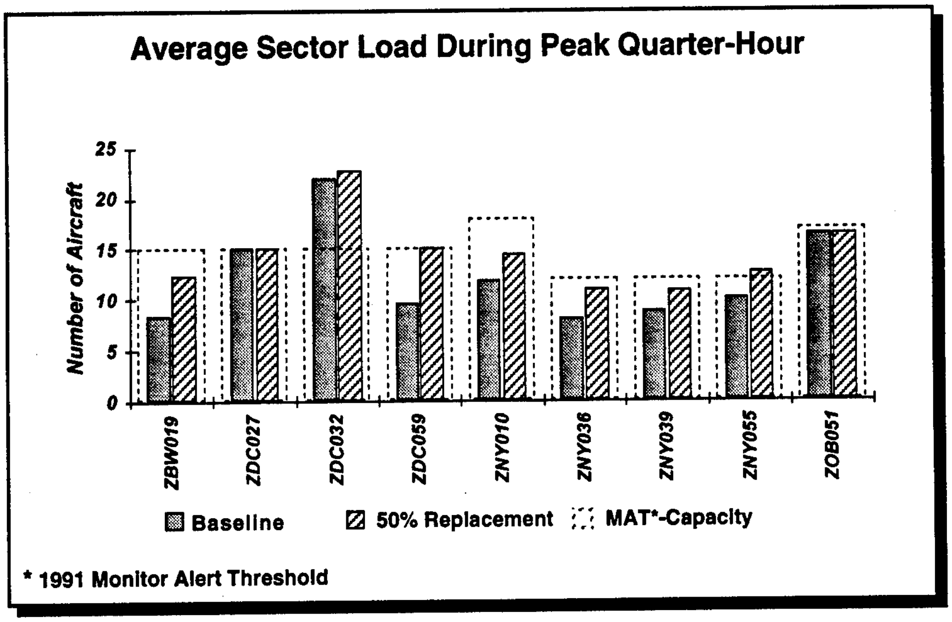
For the 1990 timeframe, only sector ZDC032 appears to be a potential problem sector with respect to the peak quarter-hour load metric. Several other sectors showed as large an increase in load, but had much lower average loads in the baseline case and so didn't become overloaded. Although sector ZDC032 may appear in this graph to have had a serious problem worsened by CTR service, the results for the entire set of six cases for this scenario (i.e., two years and three metrics) makes the severity seem much less. All other changes were much smaller, including an actual decrease when total overload duration is used as the metric.

Note that the 1990 Baseline scenario is the only case for which actual comparison data is available. Sector ZDC032 clearly appears to be heavily loaded as simulated by the NASPAC SMS and summarized in the charts on pages 18, 20, and 22. We confirmed with ZDC traffic management staff that ZDC032 is now, and has been for at least several years, a very busy sector which requires extra attention. (It includes the Gordonsville fix used by two-way traffic between Boston, New York, and Washington to the north and Atlanta and Texas to the south. Adjacent sectors are also heavily loaded and unable to handle additional traffic without also becoming overloaded.)

Baseline vs. 50% Replacement: Year 2000 Results



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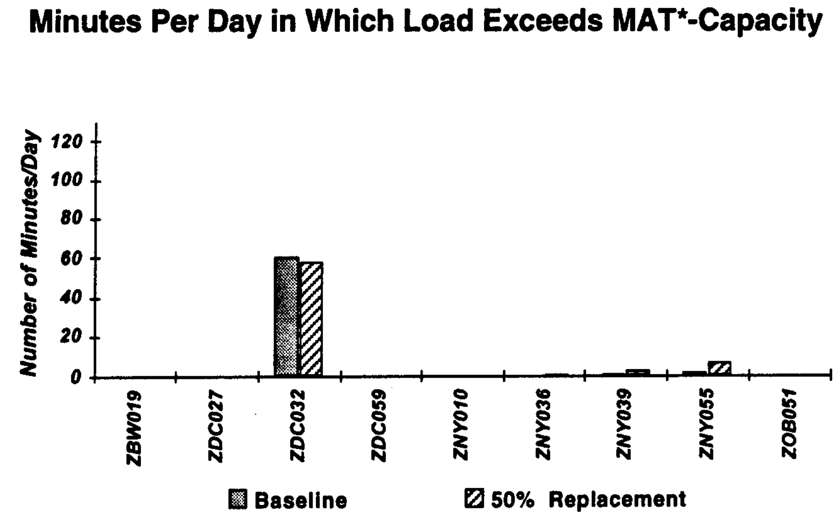
Based on FAA forecasting data, Northeast Corridor aircraft traffic is assumed to grow by about 17 percent between 1990 and 2000, so more sectors appear to be approaching their capacity limits (which are assumed to equal their 1991 MATs) in the year 2000 scenarios than in the year 1990 scenarios. Data preparation is discussed further in the appendix.

Instead of just sector ZDC032, several other sectors appear to be close to capacity in either the baseline or replacement scenarios or both. Only sector ZDC059 appears to show a significant increase in load from the baseline to the replacement scenario which could (marginally) lead to a potential overload problem. There was also a large increase there in 1990, but in that timeframe its load didn't reach the MAT.

Baseline vs. 50% Replacement: Year 1990 Results (Continued)



* 1991 Monitor Alert Threshold

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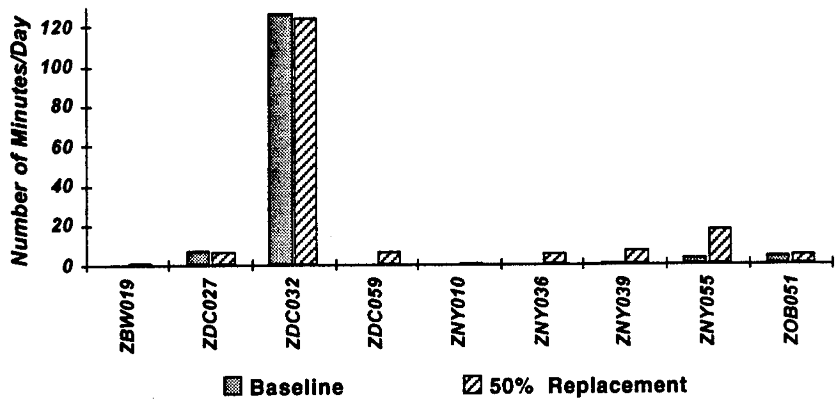
Most incidents of overload consisted of only small overages and lasted for only brief durations. Sector ZDC032 is the only sector where the sum of all durations when the instantaneous aircraft count exceeded its 1991 MAT throughout the entire day totaled more than six minutes. For this metric, sector ZDC032's overload for the year 1990 actually appears to be reduced and not aggravated by the introduction of CTR service.

Baseline vs. 50% Replacement: Year 2000 Results (Continued)

Minutes Per Day in Which Load Exceeds MAT*-Capacity



* 1991 Monitor Alert Threshold

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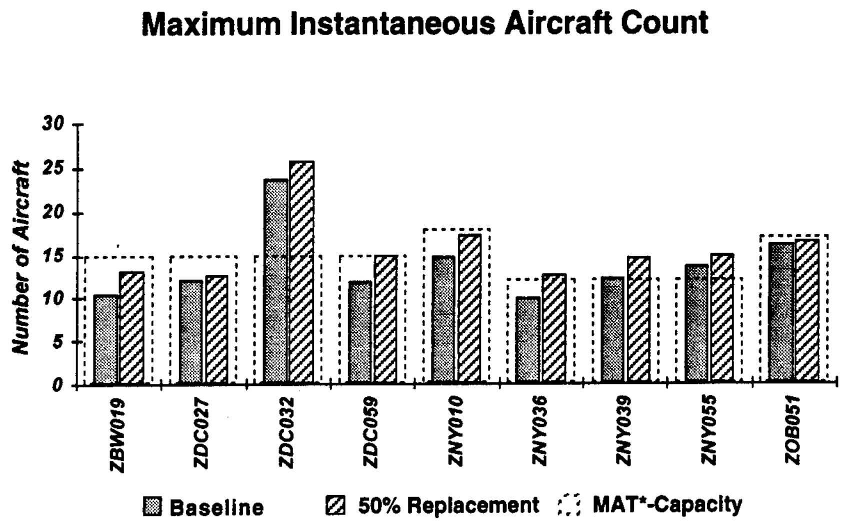
Most incidents of overload continue to be by a small amount and for only a brief duration. Sectors ZDC032 and ZNY055 are the only sectors where the sum of all durations when the instantaneous aircraft count exceeded their 1991 MAT throughout the entire day totaled more than seven minutes. For this metric, sector ZDC032's overload for the year 2000 actually appears to be reduced and not exacerbated by the introduction of CTR service. Sector ZNY055 is the only sector for which the incidence of overload appears to have noticeably increased from the baseline to the replacement scenario.

Baseline vs. 50% Replacement: Year 1990 Results (Continued)



* 1991 Monitor Alert Threshold

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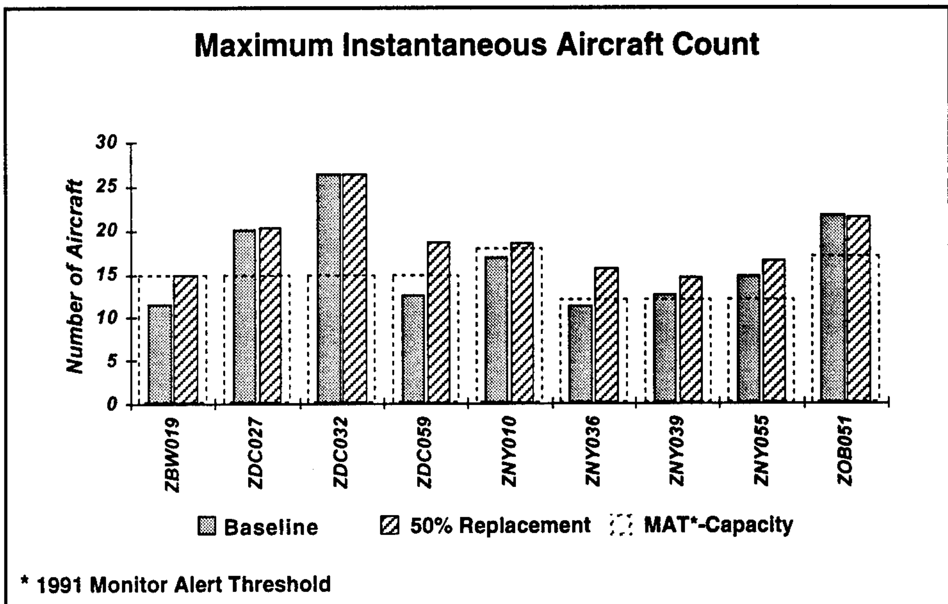
For the 50 Percent Replacement scenario, only eight sectors ever had their aircraft count exceed their 1991 MAT for even an instant during the year 1990 simulated day. Five of those eight sectors are included in the set of nine sectors which are summarized in the results charts. Results for all eight are summarized in a table in the appendix. The other three sectors are not included in the results charts because the magnitude of the overload is small (according to the criteria on page 15).

Most incidents of overload were by only a small amount and for only a brief duration. Only sector ZDC032 had its MaxIAC exceed its MAT by more than three aircraft in the replacement scenario. All of the increases in MaxIAC from the baseline to the replacement scenario for these sectors equaled three aircraft or fewer. For some sectors (not summarized in this report because they did not have potential overload problems influenced by CTR traffic), the load was reduced because of a reduction in fixed-wing traffic flying through them.

Baseline vs. 50% Replacement: Year 2000 Results (Continued)



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For the 50 Percent Replacement scenario, 16 sectors had their instantaneous aircraft count exceed their 1991 MAT at some point in time during the year 2000 simulated day. Results for all 16 are summarized in a table in the appendix. Eight of those 16 are included in the set of nine sectors which are shown here (the load at sector ZBW019 nearly reached its MAT, but not quite). The other eight are not included in the results charts because the magnitude of the overload is small (according to the criteria on page 15). Of these eight, only two sectors showed an increase in maximum load of more than two aircraft from the baseline to the replacement scenario.

Year 1990 Results Summary

Sector	MAT Capacity	Baseline Scenario: Peak 1/4-Hour Avg.Load	Baseline Scenario: Minutes w/ Load > Capacity	Baseline Scenario: MaxIAC	50% Replacement Scenario: Peak 1/4-Hour Avg.Load	50% Replacement Scenario: Minutes w/ Load > Capacity	50% Replacement Scenario: MaxIAC
ZBW019	15	7	0	11	10	0	13
ZDC027	15	9	0	12	9	0	13
ZDC032	15	20	60	24	23	58	26
ZDC059	15	8	0	12	12	0	15
ZNY010	18	10	0	15	14	0	17
ZNY036	12	7	0	10	9	0	13
ZNY039	12	8	0	12	11	2	15
ZNY055	12	9	2	14	10	6	15
ZOB051	17	13	0	16	13	0	17

Results rounded to the nearest unit

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For the 50 Percent Replacement scenario, only eight sectors ever had their aircraft count exceed their 1991 MAT for even an instant during the year 1990 simulated day. Five of those eight sectors are included in the set of nine sectors which are summarized in the results charts. Results for all eight sectors are summarized in the appendix on page 54.

Most incidents of overload were by only a small amount and for only a brief duration. Evidence of that is that ZDC032 is the only sector where the MaxIAC exceeded its MAT by more than three aircraft. It is also the only sector where the sum of all durations of overload throughout the entire day totaled more than six minutes. In practice, the overloads in the other sectors could likely be handled through fairly routine controller adjustments, and thus an overload may not actually occur in practice or else can be handled routinely as long as it is only a momentary phenomenon.

The only sector which appears to have a potentially serious overload problem is ZDC032. For it, overloads appear to be approximately the same magnitude of problem in the baseline case as in the replacement scenario. For two of the three metrics, the overload appears worse and for the third it gets better. MaxIAC's of 24 and 26 are not dramatically different from each other in comparison with an MAT of 15. Similarly, peak quarter-hour loads of 20 and 23 are not that much different versus 15, especially in light of the decrease from 60 to 58 minutes in the total daily overload duration. Thus, the overall picture is that CTRs do not appear to have a significant effect on the duration or magnitude of the overload problem there.

Year 2000 Results Summary

Sector	MAT Capacity	Baseline Scenario: Peak 1/4-Hour Avg.Load	Baseline Scenario: Minutes w/ Load > Capacity	Baseline Scenario: MaxIAC	50% Replacement Scenario: Peak 1/4-Hour Avg.Load	50% Replacement Scenario: Minutes w/ Load > Capacity	50% Replacement Scenario: MaxIAC
ZBW019	15	8	0	12	12	1	15
ZDC027	15	15	7	20	15	6	20
ZDC032	15	22	127	26	23	124	26
ZDC059	15	10	0	13	15	7	19
ZNY010	18	12	0	17	15	1	19
ZNY036	12	8	0	11	11	6	16
ZNY039	12	9	0	13	11	7	15
ZNY055	12	10	3	15	13	17	17
ZOB051	17	16	4	22	16	5	22

Results rounded to the nearest unit

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For the 50 Percent Replacement scenario, 16 sectors had their MaxIAC exceed their 1991 MAT during the year 2000 simulated day. Eight of those 16 sectors are included in the set of nine sectors which are summarized in the results charts. Results for all 16 sectors are summarized in the appendix on page 55.

Most incidents of overload were by only a small amount and for only a brief duration, with only six sectors where the MaxIAC exceeded its MAT by more than three aircraft. Of these six, only two sectors seem to show noticeable increases in their loads due to CTR: ZDC059 and ZNY039. However, in the replacement scenario they do not appear likely to pose significant problems. In summary, CTR service does not appear to exacerbate load problems.

Summary and Conclusions

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Summary and Conclusions

- Consistent pattern emerges from three metrics which identify specific potential sector overload problems:
  - Only one sector appears to have a potentially significant overload problem (ZDC032), but that problem is not due to introduction of CTRs (few removal and replacement flights involved)
  - Several other sectors (ZNY055, ZNY039, and to lesser degree ZDC027, ZDC059, and ZNY036) *may potentially* pose an overload problem, but magnitude of such a problem appears to be small
- Ultimate design and flight profile of CTRs, as well as any airspace redesign prior to introduction of CTR service, could have significant effect on which sectors may face load problems as well as severity of any problems

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By examining the results for all four demand scenarios (charts are included in both the main body of this report and in the appendix) and all three metrics for the two timeframes, a fairly consistent pattern emerges from which it is possible to draw some conclusions. These conclusions are based primarily on the year 2000 timeframe and the Baseline and 50 Percent Replacement scenario results, but also take into consideration the sensitivity analysis demand scenarios.

Of the 112 sectors examined, only one sector, ZDC032, appears to have a potentially significant overload problem; that sector's load is not noticeably affected by the introduction of CTR traffic. The input data to the analysis indicates that there were only a small number of flights affected by the baseline versus replacement scenario changes for sector ZDC032. There are several other sectors which may potentially have an overload problem (depending in part on which demand scenario one considers), but the magnitude of the problems do not appear to be great. These potential problems would not likely pose significant challenges.

The conclusions are based in part on the use of 1991 MATs as surrogates for capacity, which may be only approximately true. In addition, actual capacity is likely to be expanded by the time CTR service could be introduced due to potential advances in technology, improvements in procedures, as well as the possibility of airspace redesign as options to resolving potential overload problems. Note also that the actual flight characteristics of CTRs and their standard operating procedures would have an effect on any eventual result as well.

Summary and Conclusions (Continued)

Scenario	Overload Criteria	ZBW019	ZDC027	ZDC032	ZDC059	ZNY010	ZNY036	ZNY039	ZNY055	ZOB051	Total cases
Year 1990 Baseline	Peak 1/4-Hour Load > MAT			x							1
	Load > MAT for > 10 min/day			x							1
	MaxIAC > 130% of MAT			x							1
Year 2000 Baseline	Peak 1/4-Hour Load > MAT		x	x							2
	Load > MAT for > 10 min/day			x							1
	MaxIAC > 130% of MAT		x	x							2
Year 1990 50% Replacement	Peak 1/4-Hour Load > MAT			x							1
	Load > MAT for > 10 min/day			x							1
	MaxIAC > 130% of MAT			x							1
Year 2000 50% Replacement	Peak 1/4-Hour Load > MAT		x	x	x				x		4
	Load > MAT for > 10 min/day			x					x		2
	MaxIAC > 130% of MAT		x	x			x		x		4
Overload cases per sector (for all 24 cases)		3	5	24	5	1	5	7	12	2	

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The tables on this and the following page summarize the cases of potential overload based on the criteria listed on page 15. Regardless of which scenario is examined, for which timeframe, or which metric, only nine sectors appear to have a potential overload problem. They appear in various combinations as shown in the tables; up to seven sectors appear for any specific year/ scenario/metric case shown on either page. Because of different routes and schedules, some other sectors would actually benefit from the introduction of CTR service.

Only two sectors appear to pose a potential overload problem for the Baseline scenario shown above. Sector ZDC032 appears to face a potential problem regardless of the timeframe, metric, or demand scenario. Sector ZDC027 exceeds the peak quarter-hour load and MaxIAC criteria, but barely so, and does not exceed the ten-minute cutoff for the overload duration criterion.

Five sectors appear to potentially pose a problem for at least one of the criteria for the 50 Percent Replacement demand scenario shown above. In addition to sectors ZDC027 and ZDC032, sectors ZDC059, ZNY036 and ZNY055 appear, although only ZNY055 satisfies both the peak quarter-hour and overload duration criteria.

The peak quarter-hour load and the total duration of overload are likely the most useful criteria for identifying and quantifying potential sector overload problems. When attention is focused on the year 2000 results for those two metrics for all four demand scenarios, sectors ZDC032, ZDC059, and ZNY055 appear to be the potentially most troublesome (they appear to be potential problems in five or more of the eight cases).

Summary and Conclusions (Concluded)

Scenario	Overload Criteria / Sector	ZBW019	ZDC027	ZDC032	ZDC059	ZNY010	ZNY036	ZNY039	ZNY055	ZOB051	Total cases
Year 1990	Peak 1/4-Hour Load > MAT			✗				✗	✗		3
100%	Load > MAT for > 10 min/day			✗				✗	✗		3
Replacement	MaxIAC > 130% of MAT			✗				✗	✗		3
Year 2000	Peak 1/4-Hour Load > MAT	✗		✗	✗			✗	✗	✗	6
100%	Load > MAT for > 10 min/day	✗		✗	✗	✗	✗	✗	✗		7
Replacement	MaxIAC > 130% of MAT	✗		✗			✗	✗	✗	✗	6
Year 1990	Peak 1/4-Hour Load > MAT			✗							1
50% Repl.	Load > MAT for > 10 min/day			✗							1
with Back-fill	MaxIAC > 130% of MAT			✗							1
Year 2000	Peak 1/4-Hour Load > MAT			✗	✗		✗		✗		4
50% Repl.	Load > MAT for > 10 min/day			✗	✗			✗	✗		4
with Back-fill	MaxIAC > 130% of MAT		✗	✗			✗		✗		4
Overload cases per sector (for all 24 cases)		3	5	24	5	1	5	7	12	2	

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Eight sectors in the 100 Percent Replacement scenario satisfy one or more of the criteria and six sectors exceed one or more of the cutoffs in the 50 Percent Replacement with Backfill scenario.

As a side note, different results would appear than those shown in the tables on pages 29–30 if different criteria were applied. For example, if the cutoffs were set at MaxIAC exceeding 140 percent of the MAT, 15 minutes per day of overload, and peak quarter-hour load exceeding 105 percent of the MAT, sectors ZDC027, ZNY010, ZNY036, and ZOB051 would drop off the sector overload list. If the criteria were raised to 150 percent, 30 minutes per day, and 110 percent, respectively, only sectors ZDC032, ZNY039, and ZNY055 would remain. With these criteria, the two New York sectors appear to be potential problems only for the 100 Percent Replacement scenario.

Because loads are caused by both fixed-wing and CTR traffic, no one demand scenario is systematically worse than another—sector load may be relieved or increased when CTRs are introduced depending on the number of each type of aircraft flying through the sector, as well as the timing of the flights. In general, however, certain patterns should emerge. For example, the 50 Percent Replacement with Backfill demand scenario includes all of the traffic in both the Baseline and the 50 Percent Replacement scenarios. Thus, all potential problem sectors in those two scenarios should also appear to be potential problem sectors in the backfill scenario. Subject to minor random variation, this is true. (The only exception is sector ZDC027, where the year 2000 peak quarter-hour load in the backfill scenario is 15.0 versus 15.1 in the other two scenarios. Thus, it is basically a matter of roundoff error that sector ZDC027 does not have an ✗ in the backfill case but does in the baseline and 50 percent replacement scenarios.)

References

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References

- This analysis builds on many of the assumptions, data, and methodology used in what is referred to in this briefing as the Phase II Delay Analysis. The documentation for it should be referred to for more detail:
  - Fabrizi, M. A., Fraser, S. B., Springen, A. L., and Trigeiro, W. W., "Civil Tiltrotor Northeast Corridor Delay Analysis *(Based on the Demand Scenario Described in Civil Tiltrotor Missions and Applications Phase II: The Commercial Passenger Market)*," MTR 93W0000065, The MITRE Corporation, McLean, VA
- Original source of assumptions and data is referred to in this briefing as the Phase II Market Study:
  - "Civil Tiltrotor Missions and Applications Phase II: The Commercial Passenger Market," January 1991 (by Boeing for NASA/FAA)

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Appendix

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Terms and Concepts

- Northeast Corridor: Includes corridor airports and vertiports and the en route airspace (sectors) in centers ZBW, ZDC, ZNY, ZOB, plus parts of ZID, ZJX, ZTL
- Corridor Airports: 7 airports with collocated vertiports serving traffic to and from feeder airports/vertiports
  - Boston Logan (BOS), Newark (EWR), John F. Kennedy (JFK), New York LaGuardia (LGA), Philadelphia (PHL), Washington National (DCA), Washington Dulles (IAD)
- Corridor Vertiports: 12 vertiports strategically located in Northeast Corridor population centers (serving a self contained network of flights)
  - Boston (3), New York (6), Philadelphia (1), Washington (2)
- Feeder Airports: 69 airports with collocated vertiports located within 500 miles of a corridor airport that *feed* corridor airports

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Page 8 includes a map which shows the seven centers (ARTCC airspace) which include the sectors in the "Northeast Corridor." The map on page 36 shows the airports that are included in the definition of the Northeast Corridor. CTR routes which fly through Northeast Corridor airspace are shown on a map on page 38.

The Northeast Corridor airports and vertiports and the flights between them can be classified as either "corridor" or "feeder." Corridor flights connect corridor airports/vertiports with other corridor airports/vertiports whereas feeder flights connect feeder airports/vertiports to corridor airports/vertiports.

Terms and Concepts (Continued)

- **<u>Phase II Market Capture</u>: A scenario in which scheduled fixed-wing flights, identified in the *Phase II Market Study* as candidates for CTR replacement, are removed and replaced by CTRs—either all (100 percent replacement) or half (50 percent replacement) of identified flights are used**
  - **Assume no effect on general aviation or military flights**
- **<u>Removal Flights</u>: Fixed-wing flights which are assumed to be replaced by CTR flights; they are removed from air carrier scheduled demand**
- **<u>Replacement Flights</u>: CTR flights are inserted into the air carrier schedule in place of fixed-wing removal flights as part of the market capture process**
  - **Based on the size of the aircraft removed replacement by a 40-seat CTR, on a seat-by-seat substitution rate**

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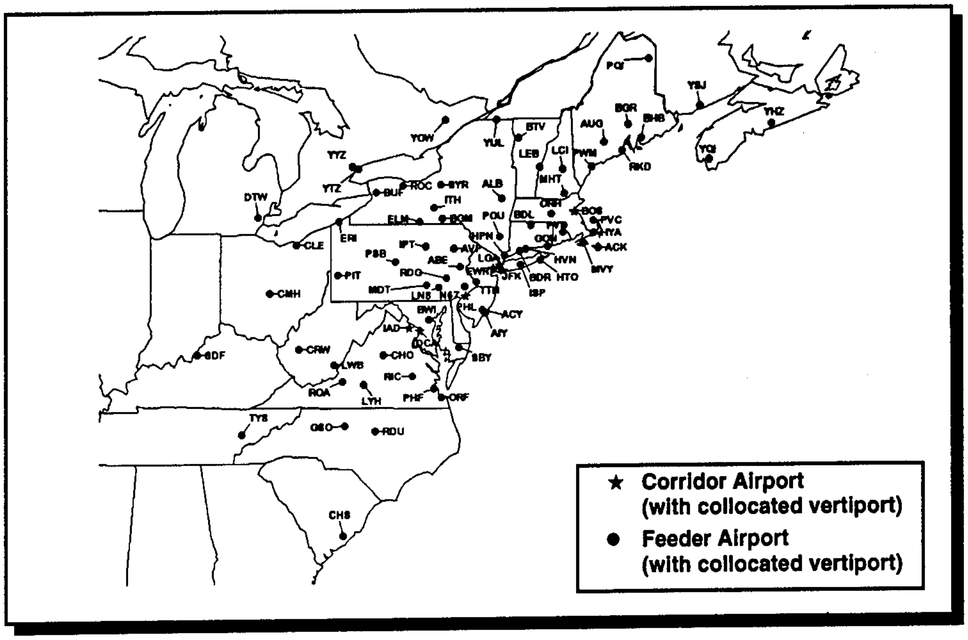
The definitions above are relatively straightforward with the possible exception of the "seat-by-seat substitution rate" used for generating CTR replacement flights. The flights which were identified as captured by CTR service were examined for equipment type, and thus for passenger seating capacity. The number of CTR flights generated was sufficient in number to provide an equal number of passenger seats (based on a 40-seat CTR design, per assumption on page 37).

For flights between corridor and feeder airports, which primarily consisted of turboprop traffic, there was an average of four CTR replacement flights for every five fixed-wing removal flights (i.e., the average size of the removal flights was about 32 seats, so introducing CTRs actually *reduced* feeder traffic from 841 flights to 680 flights in 1990). For flights between corridor airports, which consisted mostly of jet traffic, seven CTR replacement flights were generated in place of every two fixed-wing removal flights on average (i.e., the average size of a fixed-wing aircraft used as a removal flight was about 140 seats, thus increasing the number of corridor flights in 1990 from 124 to 435). Thus, there was a 0.8 to 1 substitution for feeder flights and a 3.5 to 1 substitution for corridor flights.

As shown on page 43, the CTR replacement schedule was constructed so as to maintain a time-of-day pattern consistent with the corresponding removal traffic schedule.

Terms and Concepts (Concluded)



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The Northeast Corridor, as defined in this report, consists of seven corridor airports (listed on page 34) and their collocated vertiports, 69 feeder airports with collocated vertiports, and 12 non-collocated vertiports strategically located near population centers in Boston, New York, Philadelphia, and Washington, DC. The en route sectors through which flights between these airports and vertiports fly provides the corresponding airspace definition of the Northeast Corridor.

Additional Analysis Assumptions

- Infrastructure necessary for CTR operations exists (e.g., vertiports, GNSS)
- Capacities enforced at fixed-wing airports, unconstrained at vertiports
- All Visual Meteorological Conditions (VMC) weather
- CTRs operate in existing en route NAS with static sector geometries, for both year 1990 and year 2000 timeframes
- 1991 MATs used as surrogates for sector capacities
- CTRs are assigned current ATC Preferred IFR Routes
- CTRs have 40 passenger seats and will have same average load factor as current fixed-wing aircraft

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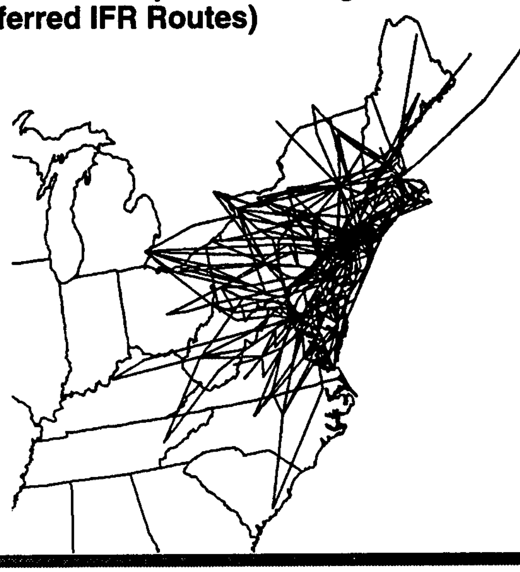
CTR and fixed-wing traffic is assumed to be able to take advantage of advanced technology not yet in place which is necessary for the introduction of CTR service. In particular, this includes the use of GPS based navigation in the terminal area environment, vertiports, and potential redesign of terminal area airspace with revised terminal procedures to accommodate CTRs in the terminal area environment. In the en route airspace environment, current day sector geometries, MATs, procedures, and routes are assumed. We do not enforce capacities at vertiports in this study.

The assumption of all VMC weather was made because it is a conservative assumption with respect to en route airspace loads. During VMC conditions there are more aircraft flying in general, and more importantly, air carrier traffic tend to more closely follow their schedules, which have significant demand peaks built in. (Note that MATs are the same for all demand and weather conditions.) VMC provides a busy traffic day in the en route airspace environment in comparison with days with some IMC conditions.

CTR size and performance characteristics are based on current (1994) plans by Bell Helicopter and Boeing Helicopter.

Additional Analysis Assumptions (Concluded)

Northeast Corridor CTR *replacement* flights (using ATC Preferred IFR Routes)



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CTRs are assigned to current day ATC preferred IFR routes. This has the effect of using routes which are consistent with the sector boundaries and aircraft schedules used for the simulation. These routes are generally consistent with routes that would be used by high performance turboprop fixed-wing aircraft through the en route environment, and does not allow for taking direct routes or less congested routes to reduce flight time and distance between vertiports.

Note that these are not necessarily the routes which would be taken when exploiting new technologies and procedures, such as GPS or airspace redesign, which would likely be necessary in order to take advantage of CTR performance characteristics. However, there is currently no information on how these changes might be implemented, so the intent here is to perform the simulation with a consistent set of data and assumptions. In this case, consistency of airspace geometries and routes was the overriding concern.

Scenario Definition and Data Preparation

- **Capacities at fixed-wing airports for year 2000 based on improvements included in 1991–1992 *Aviation System Capacity Plan***
- **Sector geometries and MATs taken from 1991 ARTCC Adaptation Controlled Environment System (ACES) data**
  - **Used for both year 1990 and year 2000 timeframes**

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Airport capacities were the same ones used in the Phase II Delay Analysis. That report should be referenced for more detail. Standard sets of NASPAC capacities were used for airports; sources of these capacities include the FAA Airfield Capacity Model, FAA Engineering Performance Standards (EPS), as well as airport capacity questionnaires completed by tower personnel. For the year 2000 data, these year 1990 capacities were updated to reflect procedures and airfield capacity improvements that are included in the 1991–1992 *Aviation System Capacity Plan* and are due to be implemented by 2000.

In the en route airspace environment, current day sector geometries and MATs (as surrogates for capacity) are assumed. In particular, our source was the 1991 ACES data, the latest available at the time this study began. The same airspace design and capacity data were used for both the year 1990 and year 2000 analyses.

Scenario Definition and Data Preparation (Continued)

- **Year 1990 count of fixed-wing plus CTR flights in and out of seven airports and 19 vertiports in Northeast Corridor**

	Baseline	50% Replacement	100% Replacement	50% Repl. w/ Backfill
First 50% Fixed-Wing Removals	965			965
Next 50% Fixed-Wing Removals	965	965		965
First 50% CTR Replacements		1,115	1,115	1,115
Next 50% CTR Replacements			1,115	
All Other Fixed-Wing Aircraft	3,790	3,790	3,790	3,790
Total Flights	5,720	5,870	6,020	6,835

AOR MITRE

The chart above shows counts of fixed-wing and CTR flights in the Northeast Corridor. Note that these numbers do not match those shown on page 43 because these are flights and the chart on page 43 shows operations. Each flight to and from the 7 corridor airports and 19 vertiports results in two operations, both an arrival and a departure. However, for feeder flights, which have either an arrival or a departure outside the corridor network, only one operation per flight occurs. Comparing the Baseline versus the 50 Percent Replacement scenario increases the number of Northeast Corridor flights by 150, but increases airport operations by about 460 (311 additional corridor flights and 161 fewer feeder flights results in 461 additional operations per the substitution rates discussed on page 35).

When counts of ***operations*** at airports and vertiports are examined, the corresponding number of operations (in comparison to the final row of the chart above) for the four scenarios are:

- Baseline demand scenario: 6,150
- 50 Percent Replacement: 6,610
- 100 Percent Replacement: 7,070
- 50 Percent Replacement with Backfill: 7,700

Scenario Definition and Data Preparation (Continued)

- **CTR performance characteristics**
  - **Coordinated with Boeing and Bell**
- **CTR removal and replacement schedules**
  - **Year 1990 (adapted from data from Boeing)**
  - **Year 2000 air carrier demand based on growth rates from 1993 Terminal Area Forecast; zero growth assumed for general aviation and military traffic**
- **Vertiport locations (data from Boeing)**
  - **12 vertiports serving CTR corridor replacement flights**
  - **7 vertiports (collocated with corridor airports) and 69 vertiports (collocated with feeder airports)**

AOR MITRE

Operational performance characteristics of the CTR were coordinated with Boeing Helicopter and Bell Helicopter (based on their plans in 1994). Note that the planned capabilities of the CTR are a moving target, as new ideas and information arise.

Demand schedules for fixed-wing removal data and CTR corridor flights came from Boeing Commercial Aircraft Group as part of the Phase II Market Study. As mentioned previously, CTR feeder flights were constructed by performing a seat-by-seat replacement of fixed-wing feeder removal flights.

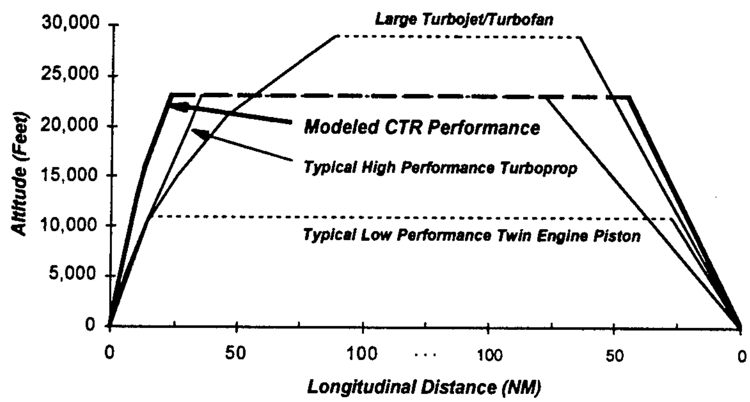
Demand for the year 1990 commercial traffic came from the February 1990 Official Airline Guide (OAG). A Thursday schedule, the busiest day of the week, was chosen in order to provide a busy traffic day. The 1990 demand was projected to the year 2000 by applying the growth rates from the FAA's 1993 Terminal Area Forecast (TAF), the latest available at this time. A zero growth rate was assumed for general aviation and military aircraft.

CTR traffic was projected to the year 2000 from the baseline of 1990 traffic which was available from the Phase II Market Study. Growth rates for the 19 corridor vertiports were set equal to an average of the growth rates in the TAF for all nearby airports. The basis for this assumption was that the growth may be different than for the nearby fixed-wing airport, especially for slot controlled airports.

The number of vertiports and their locations were obtained from Boeing Commercial Aircraft Group. Feeder airports are assumed to have collocated vertiports.

Scenario Definition and Data Preparation (Continued)

Comparison of Desired Climb/Cruise/Descent Flight Profiles of CTR and Replaced Fixed-Wing Aircraft

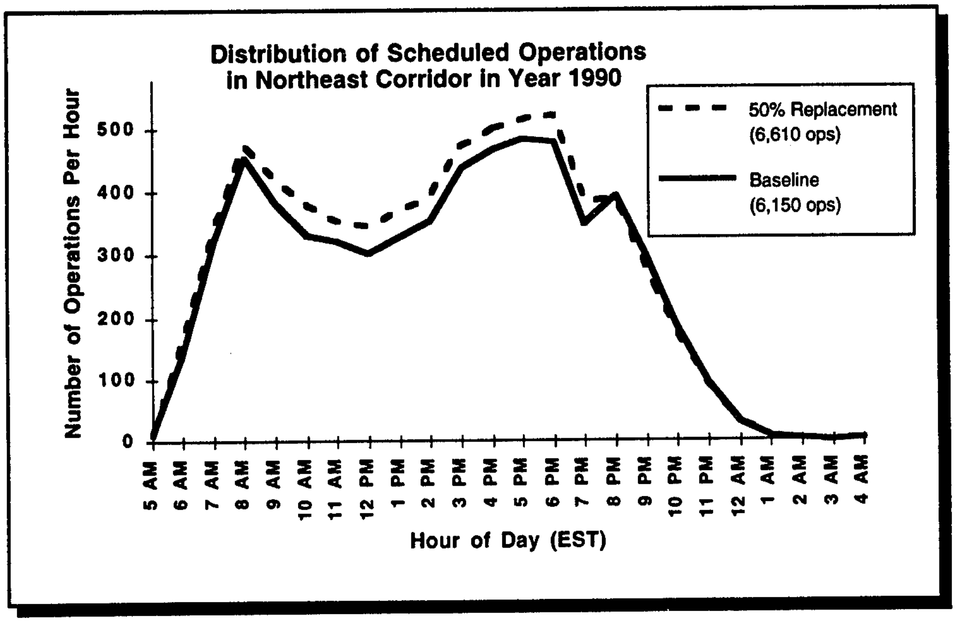


Note that the profiles used by the NASPAC SMS for most scheduled fixed-wing flights are based on actual tracks from Host Z-data

AOR MITRE

CTRs have the ability to climb and descend with a steeper slope than typical modern-day high performance turboprop aircraft. However, when in cruise mode, they are assumed to function with flight characteristics similar to high performance turboprops. Since this analysis examines en route airspace only, CTRs essentially appear to be high performance turboprops except for slight differences in their routes, particularly near the boundaries between terminal and en route airspace during climb or descent mode.

Scenario Definition and Data Preparation (Concluded)



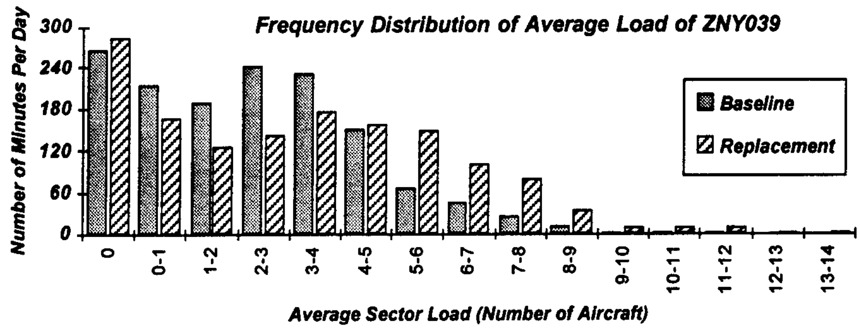
AOR MITRE

The 50 percent fixed-wing removal and CTR replacement schedules were constructed by selecting a subset of flights from the full set of removal and replacement flights used in the Phase II Market Study. The criterion was to maintain as closely as possible the desired 50 percent of seats and aircraft flights for each origin–destination airport pair. In addition, a similar schedule in terms of time-of-day distribution was maintained.

As a result of this method of constructing the year 2000 demand, the 1990 demand was just inflated by the appropriate rates using growth factors for aircraft operations (not passenger count) published by the FAA. This presupposes no changes in the patterns of air carrier activity, and tends to further exacerbate the *peaking* which is now associated with hub-and-spoke activities.

Definition/Discussion of Metrics

- **Perspective: View sector load results as various measures of an underlying frequency distribution of load during a typical (simulated) period of time**
  - **X-axis: Number of aircraft in sector ("sector load")**
  - **Y-axis: Time for which load equals given load factor**



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The three metrics can be viewed from the perspective of a frequency distribution which shows what proportion of time a sector has a particular simulated aircraft load.

Thus, the average sector load during the peak quarter-hour is calculated as the maximum of a rolling average load over 15 consecutive minutes at any time during the simulated day. One-minute average loads were calculated and all possible combinations of sustained, continuous load were examined (not just those falling on the quarter-hour of the clock).

The number of minutes per day in which the sector load exceeds its capacity is based on adding up all of the occurrences (frequencies) for which the sector load exceeds the MAT in the frequency distribution. This metric is not limited by *consecutive* time units or by the *extent* to which the load exceeds the MAT. However, it is highly sensitive to the use of the 1991 MATs as surrogates for capacity.

The MaxIAC is the farthest point to the right of the frequency distribution (X-axis) with a nonzero frequency, regardless of its likelihood. It is the load level that is never exceeded, a measure of the peak instantaneous load without regard for its sustainability.

Additional Results (Overview)

- Replacement scenario using 100 percent of Phase II Market Study market capture rates
  - Average sector load during peak quarter-hour
  - MaxIAC
  - Minutes per day with load greater than MAT
- 50 percent market capture with backfill
  - Average sector load during peak quarter-hour
  - MaxIAC
  - Minutes per day with load greater than MAT

AOR MITRE

On the following pages are additional summaries of results. First are tables providing the results of the nine sectors included in the charts that follow. These charts are the equivalent of the charts on pages 24–25, but for the two sensitivity analysis demand scenarios.

Next are graphs of the results comparing Baseline versus the 100 Percent Replacement and 50 Percent Replacement with Backfill scenarios for the year 1990 and year 2000 timeframes. These graphs, on pages 48–53, show the average peak quarter-hour sector load, the minutes per day in which the sector load exceeds the 1991 MAT, and the MaxIAC for the nine sectors discussed on pages 15–16.

Finally, on pages 54–59, charts summarize the metrics for ***all*** sectors for which the MaxIAC exceeded the 1991 MATs. For all of the other sectors, the load never exceeded the MAT at any point during the day. Results are included for all combinations of demand, timeframe, and metric.

Summary of Additional Results For Year 1990 Analysis

Sector	MAT Capacity	Baseline Scenario: Peak 1/4-Hour Avg.Load	Baseline Scenario: Minutes w/ Load > Capacity	Baseline Scenario: MaxIAC	100% Replacement Scenario: Peak 1/4-Hour Avg.Load	100% Replacement Scenario: Minutes w/ Load > Capacity	100% Replacement Scenario: MaxIAC
ZBW019	15	7	0	11	11	1	16
ZDC027	15	9	0	12	8	0	12
ZDC032	15	20	60	24	23	59	27
ZDC059	15	8	0	12	12	0	16
ZNY010	18	10	0	15	17	4	20
ZNY036	12	7	0	10	10	3	15
ZNY039	12	8	0	12	13	24	17
ZNY055	12	9	2	14	13	31	17
ZOB051	17	13	0	16	14	0	18

Results rounded to the nearest unit

AOR MITRE

Summary of Additional Results For Year 2000 Analysis (Continued)

Sector	MAT Capacity	Baseline Scenario: Peak 1/4-Hour Avg.Load	Baseline Scenario: Minutes w/ Load > Capacity	Baseline Scenario: MaxIAC	100% Replacement Scenario: Peak 1/4-Hour Avg.Load	100% Replacement Scenario: Minutes w/ Load > Capacity	100% Replacement Scenario: MaxIAC
ZBW019	15	8	0	12	16	27	21
ZDC027	15	15	7	20	15	6	19
ZDC032	15	22	127	26	24	122	27
ZDC059	15	10	0	13	15	18	18
ZNY010	18	12	0	17	17	14	23
ZNY036	12	8	0	11	12	11	17
ZNY039	12	9	0	13	13	50	17
ZNY055	12	10	3	15	14	63	18
ZOB051	17	16	4	22	18	8	23

Results rounded to the nearest unit

AOR MITRE

Summary of Additional Results For Year 1990 Analysis (Continued)

Sector	MAT Capacity	Baseline Scenario: Peak 1/4-Hour Avg.Load	Baseline Scenario: Minutes w/ Load > Capacity	Baseline Scenario: MaxIAC	50% Replacement w/ Backfill: Peak 1/4-Hour Avg.Load	50% Replacement w/ Backfill: Minutes w/ Load > Capacity	50% Replacement w/ Backfill: MaxIAC
ZBW019	15	7	0	11	10	0	13
ZDC027	15	9	0	12	8	0	12
ZDC032	15	20	60	24	20	62	23
ZDC059	15	8	0	12	12	0	15
ZNY010	18	10	0	15	14	0	17
ZNY036	12	7	0	10	10	0	13
ZNY039	12	8	0	12	10	3	14
ZNY055	12	9	2	14	11	10	16
ZOB051	17	13	0	16	13	0	17

Results rounded to the nearest unit

AOR MITRE

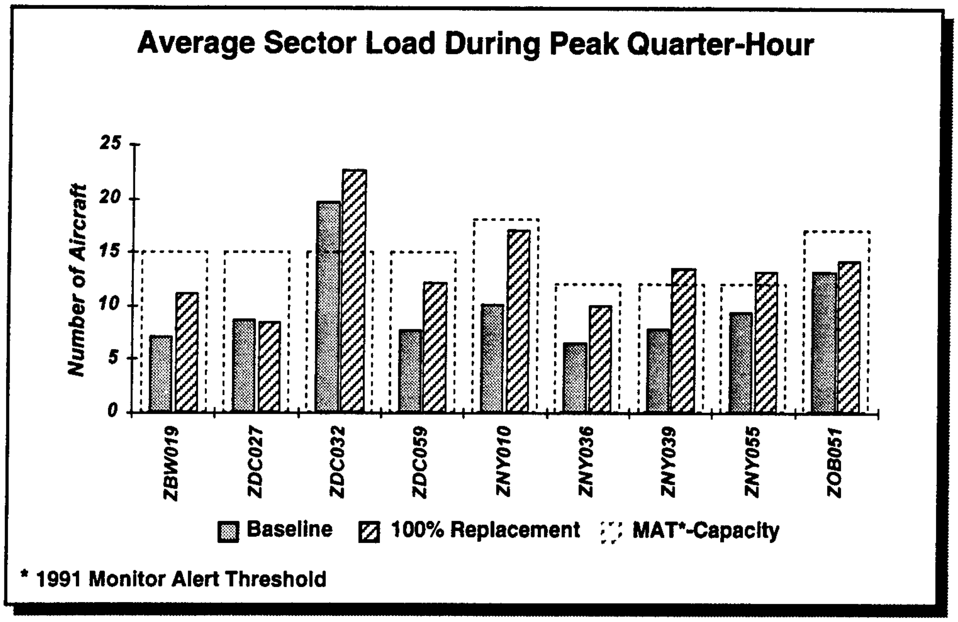
Summary of Additional Results For Year 2000 Analysis (Concluded)

Sector	MAT Capacity	Baseline Scenario: Peak 1/4-Hour Avg.Load	Baseline Scenario: Minutes w/ Load > Capacity	Baseline Scenario: MaxIAC	50% Replacement w/ Backfill: Peak 1/4-Hour Avg.Load	50% Replacement w/ Backfill: Minutes w/ Load > Capacity	50% Replacement w/ Backfill: MaxIAC
ZBW019	15	8	0	12	13	1	16
ZDC027	15	15	7	20	15	7	20
ZDC032	15	22	127	26	21	128	26
ZDC059	15	10	0	13	16	11	19
ZNY010	18	12	0	17	14	0	19
ZNY036	12	8	0	11	12	8	16
ZNY039	12	9	0	13	11	11	15
ZNY055	12	10	3	15	13	28	18
ZOB051	17	16	4	22	17	6	22

Results rounded to the nearest unit

AOR MITRE

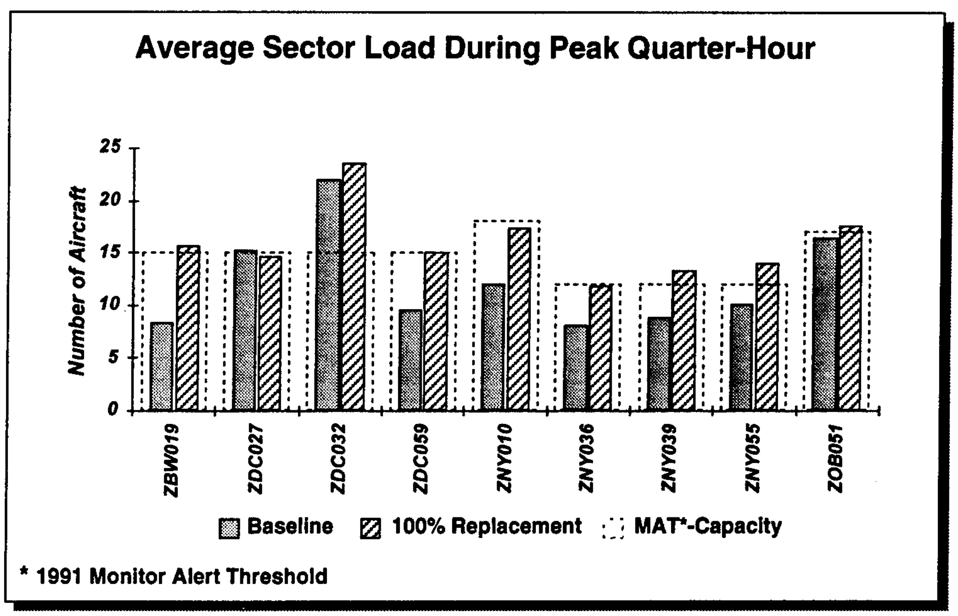
Baseline vs. 100% Replacement (for Year 1990)



AOR

MITRE

Baseline vs. 100% Replacement (for Year 2000)



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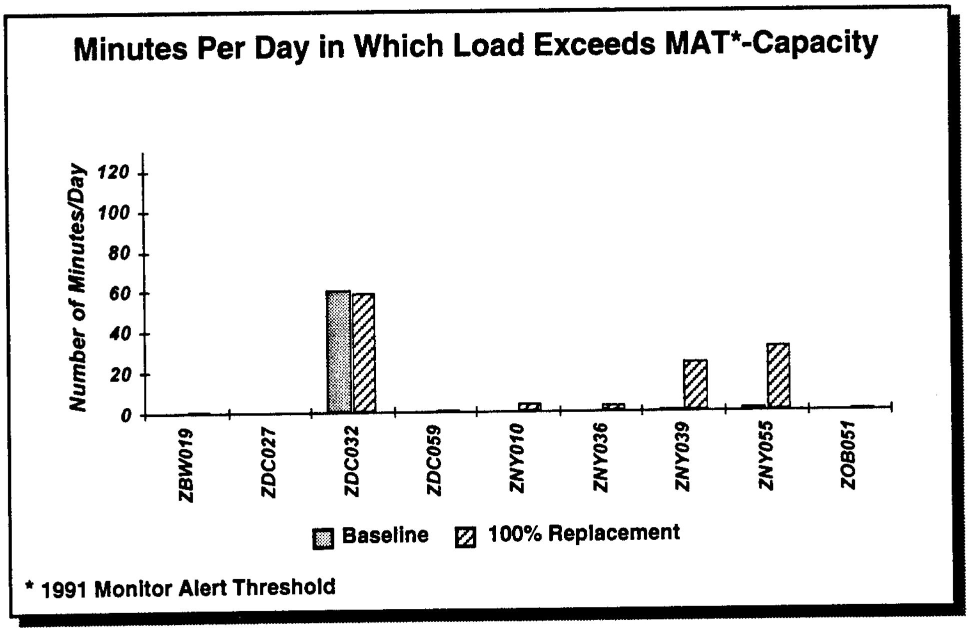
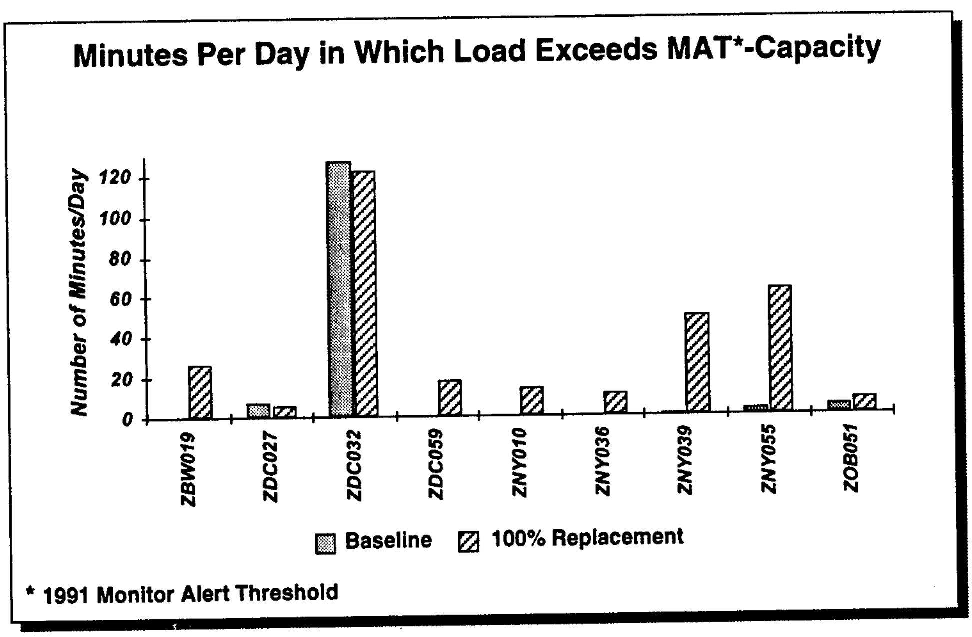
MITRE

Baseline vs. 100% Replacement (for Year 1990)



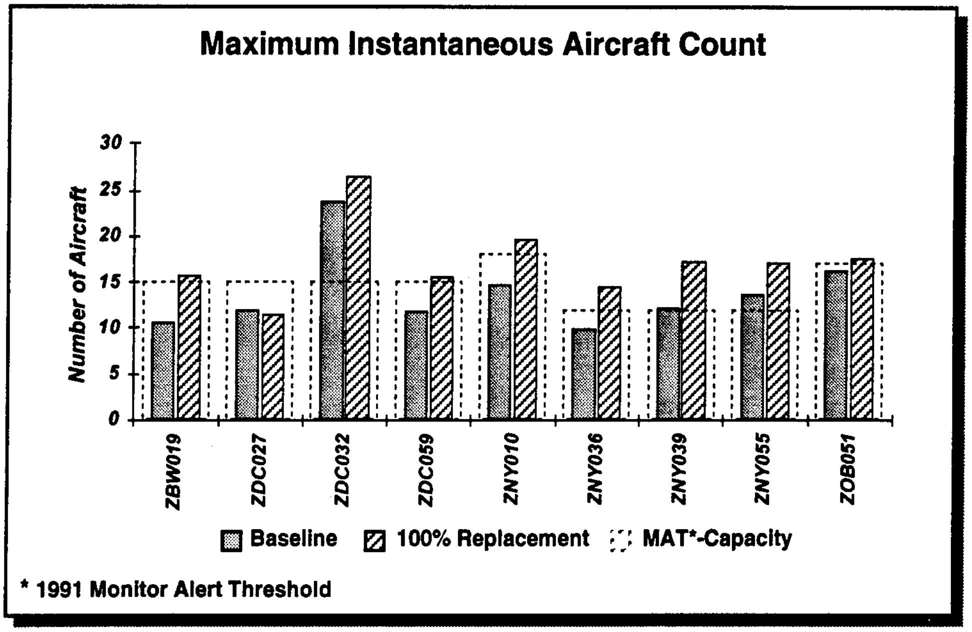
AOR MITRE

Baseline vs. 100% Replacement (for Year 2000)



AOR MITRE

Baseline vs. 100% Replacement (for Year 1990)



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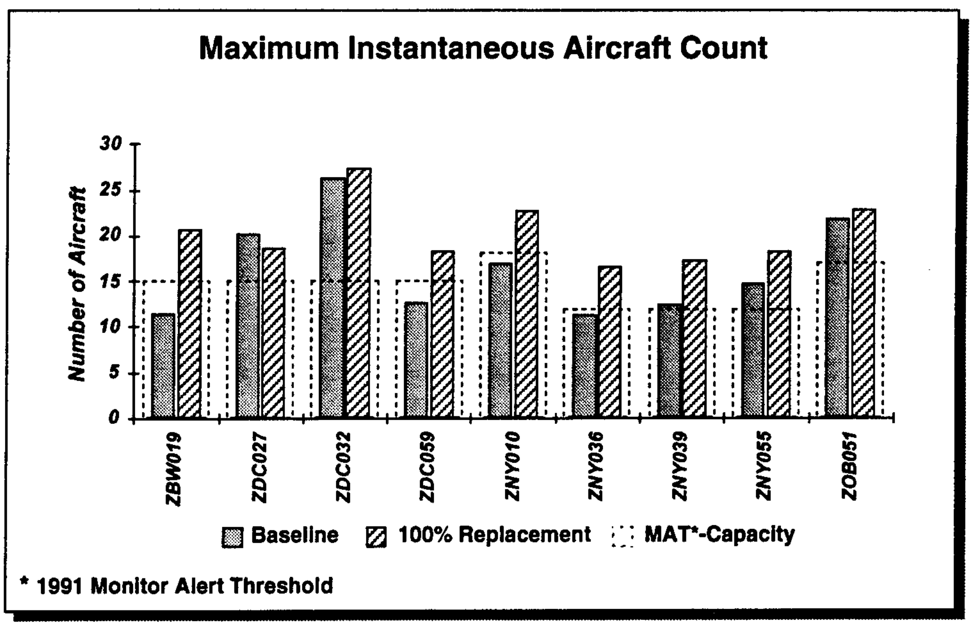
MITRE

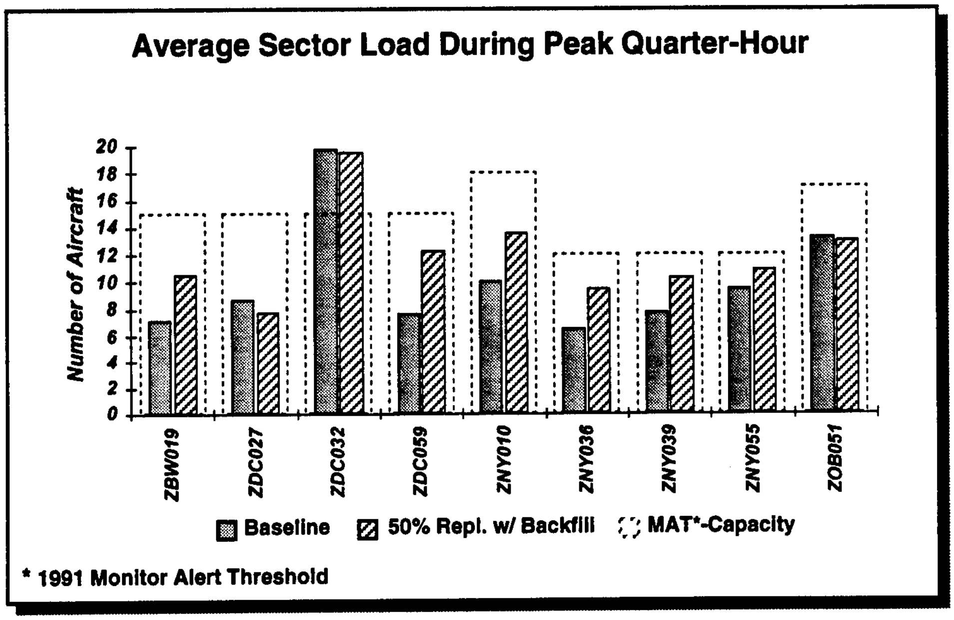
Baseline vs. 100% Replacement (for Year 2000)



AOR

MITRE

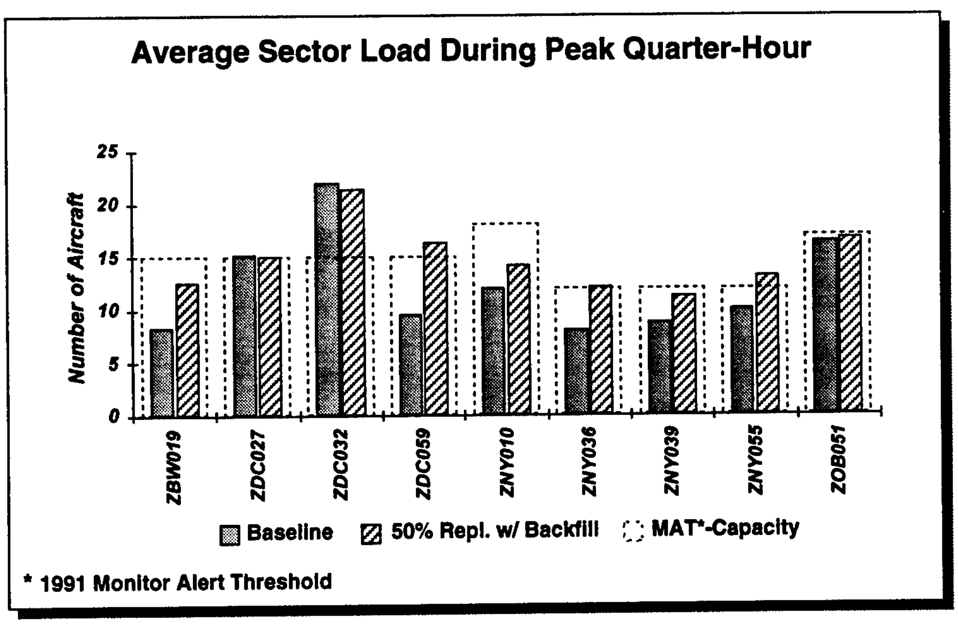
Baseline vs. 50% Replacement with Backfill (for Year 1990)



AOR

MITRE

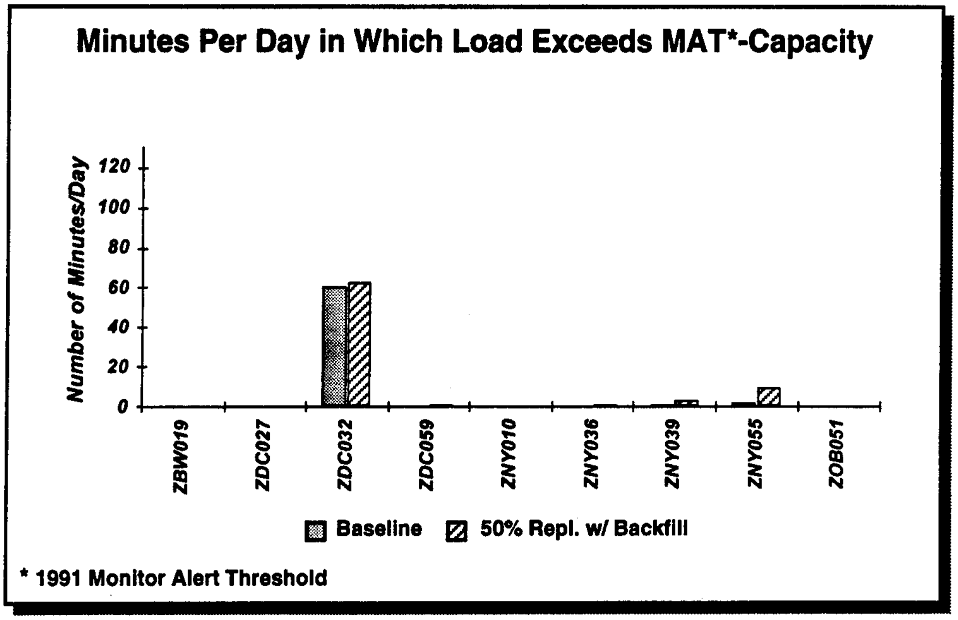
Baseline vs. 50% Replacement with Backfill (for Year 2000)



AOR

MITRE

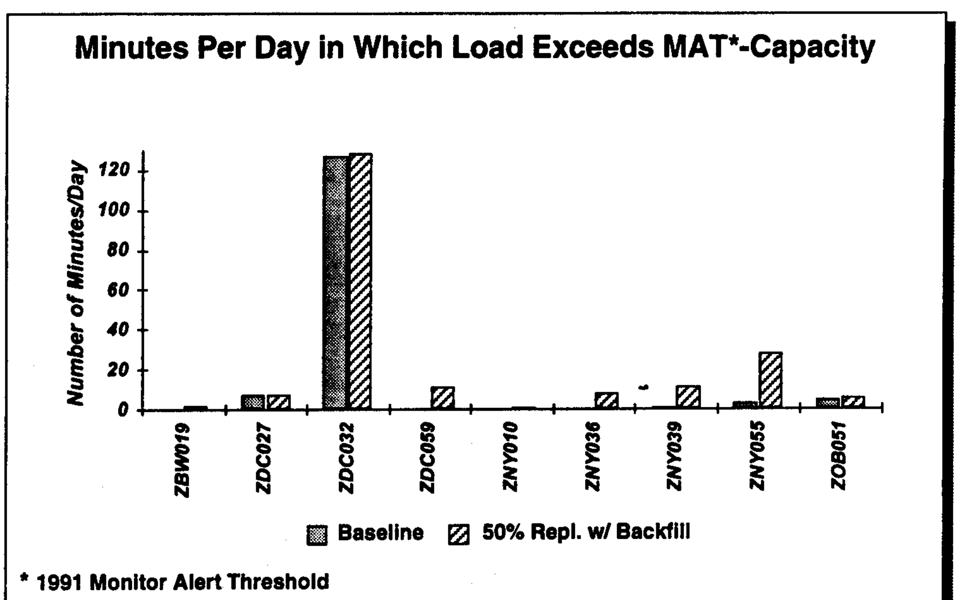
Baseline vs. 50% Replacement with Backfill (for Year 1990)



AOR

MITRE

Baseline vs. 50% Replacement with Backfill (for Year 2000)



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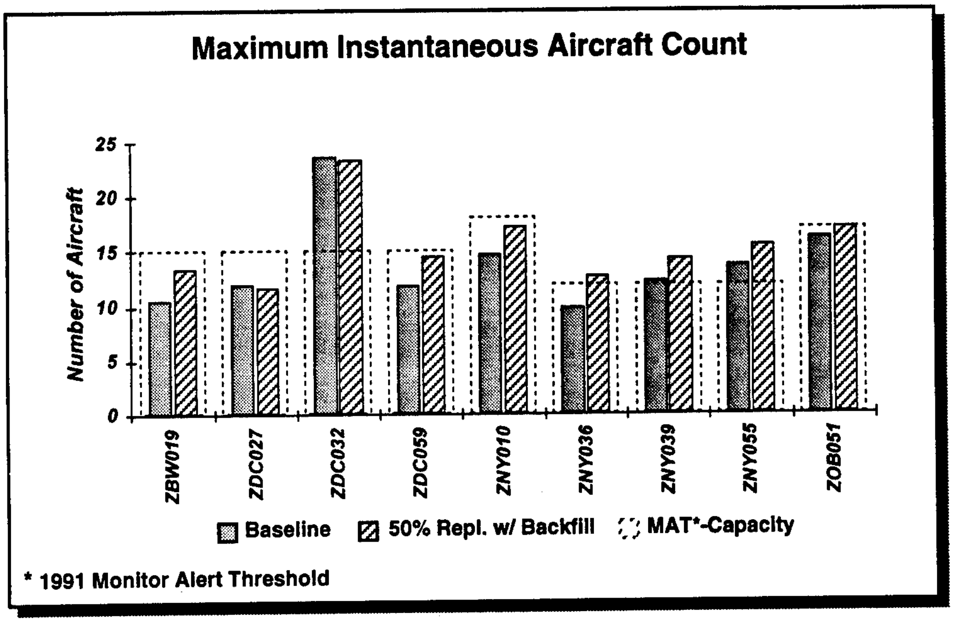
MITRE

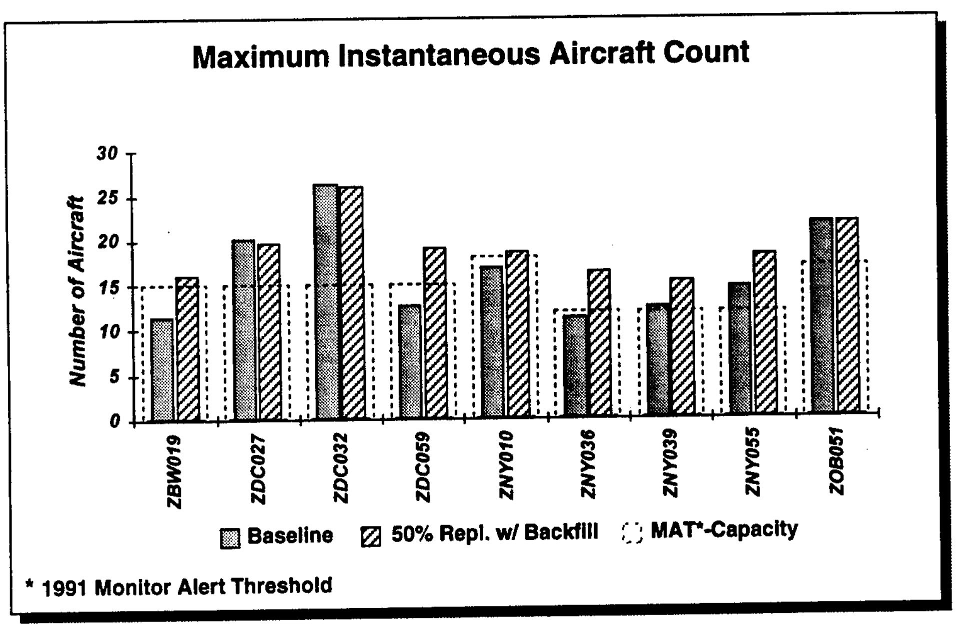
Baseline vs. 50% Replacement with Backfill (for Year 1990)



AOR

MITRE

Baseline vs. 50% Replacement with Backfill (for Year 2000)



AOR

MITRE

Baseline vs. 50% Replacement (for Year 1990)

Results for All Sectors with MaxIAC > MAT

		Baseline Scenario			50% Replacement Scenario		
Sector	MAT Capacity	Peak 1/4-Hour Avg.Load	Minutes w/ Load > Capacity	MaxIAC	Peak 1/4-Hour Avg.Load	Minutes w/ Load > Capacity	MaxIAC
ZDC032	15	20	60	24	23	58	26
ZNY039	12	8	0	12	11	2	15
ZDC020	16	14	3	18	14	4	19
ZNY055	12	9	2	14	10	6	15
ZDC054	16	13	0	16	14	2	17
ZDC059	15	8	0	12	12	0	15
ZDC019	15	12	1	15	11	0	15
ZNY036	12	7	0	10	9	0	13

Results rounded to the nearest unit

AOR

MITRE

As mentioned on page 45, this and the following pages provide summary charts of the metrics for all sectors for which MaxIAC exceeds the 1991 MAT. The purpose is to provide exhaustive lists of the results for reference purposes. Sectors which were not already summarized in the earlier charts and tables have a relatively small overload. In most cases, although the MaxIAC exceeds the MAT there is otherwise little evidence of an overload problem.

For the 50 Percent Replacement scenario, eight sectors had their MaxIAC exceed their 1991 MAT for some period of time during the year 1990 simulated day. The results for all eight sectors are included in this table. All other sectors were within their capacity limit for the entire day.

Baseline vs. 50% Replacement (for Year 2000)

Results for All Sectors with MaxIAC > MAT

Sector	MAT Capacity	Baseline Scenario: Peak 1/4-Hour Avg.Load	Baseline Scenario: Minutes w/ Load > Capacity	Baseline Scenario: MaxIAC	50% Replacement Scenario: Peak 1/4-Hour Avg.Load	50% Replacement Scenario: Minutes w/ Load > Capacity	50% Replacement Scenario: MaxIAC
ZDC032	15	22	127	26	23	124	26
ZNY055	12	10	3	15	13	17	17
ZDC059	15	10	0	13	15	7	19
ZDC027	15	15	7	20	15	6	20
ZOB051	17	16	4	22	16	5	22
ZNY036	12	8	0	11	11	6	16
ZNY039	12	9	0	13	11	7	15
ZDC054	16	12	0	16	13	1	17
ZDC020	16	14	5	19	13	4	19
ZOB034	17	13	0	17	14	0	18
ZNY010	18	12	0	17	15	1	19
ZNY066	16	11	0	15	13	0	16
ZDC019	15	12	1	16	12	2	16
ZDC018	14	11	1	15	11	2	15
ZNY075	18	13	0	18	14	1	19
ZOB048	17	12	0	17	12	1	18

Results rounded to the nearest unit

AOR MITRE

For the 50 Percent Replacement scenario, 16 sectors had their MaxIAC exceed their 1991 MAT for some period of time during the year 2000 simulated day. The results for all 16 sectors are included in this table. All other sectors were within their capacity limit for the entire day.

Baseline vs. 100% Replacement (for Year 1990)

Results for All Sectors with MaxIAC > MAT

		Baseline Scenario			100% Replacement Scenario		
Sector	MAT Capacity	Peak 1/4-Hour Avg.Load	Minutes w/ Load > Capacity	MaxIAC	Peak 1/4-Hour Avg.Load	Minutes w/ Load > Capacity	MaxIAC
ZDC032	15	20	60	24	23	59	27
ZNY039	12	8	0	12	13	24	17
ZNY055	12	9	2	14	13	31	17
ZNY010	18	10	0	15	17	4	20
ZDC020	16	14	3	18	14	3	18
ZOB051	17	13	0	16	14	0	18
ZDC054	16	13	0	16	13	1	17
ZNY036	12	7	0	10	10	3	15
ZDC059	15	8	0	12	12	0	16
ZBW031	15	7	0	10	11	0	15
ZBW019	15	7	0	11	11	1	16
ZNY075	18	12	0	17	13	0	18

Results rounded to the nearest unit

AOR MITRE

For the 100 Percent Replacement scenario, 12 sectors had their MaxIAC exceed their 1991 MAT for some period of time during the year 1990 simulated day. The results for all 12 sectors are included in this table. All other sectors were within their capacity limit for the entire day.

Other than the sectors previously summarized, only sector ZBW031 showed a noticeable increase in load from the baseline to replacement scenario, with its peak quarter-hour load increasing from 7 to 11 aircraft and its MaxIAC increasing from 10 to 15 aircraft. However, these values are still small enough in comparison to the MAT of 15 aircraft that the sector does not appear to be a likely overload candidate.

Baseline vs. 100% Replacement (for Year 2000)

Sector	MAT Capacity	Baseline Scenario: Peak 1/4-Hour Avg.Load	Baseline Scenario: Minutes w/ Load > Capacity	Baseline Scenario: MaxIAC	100% Replacement Scenario: Peak 1/4-Hour Avg.Load	100% Replacement Scenario: Minutes w/ Load > Capacity	100% Replacement Scenario: MaxIAC
ZDC032	15	22	127	26	24	122	27
ZNY055	12	10	3	15	14	63	18
ZNY039	12	9	0	13	13	50	17
ZBW019	15	8	0	12	16	27	21
ZOB051	17	16	4	22	18	8	23
ZDC059	15	10	0	13	15	18	18
ZNY036	12	8	0	11	12	11	17
ZDC027	15	15	7	20	15	6	19
ZNY010	18	12	0	17	17	14	23
ZNY066	16	11	0	15	15	7	19
ZBW031	15	10	0	14	14	4	17
ZOB034	17	13	0	17	15	3	19
ZBW047	20	11	0	15	17	1	21
ZDC020	16	14	5	19	14	4	18
ZDC017	16	8	0	12	14	2	17
ZBW024	15	9	0	13	13	1	16
ZDC054	16	12	0	16	13	1	16
ZNY025	14	9	0	13	11	1	14
ZDC019	15	12	1	16	12	2	16
ZNY075	18	13	0	18	14	1	19
ZDC018	14	11	1	15	11	0	14
ZOB066	16	12	0	16	12	0	17
ZNY042	12	8	0	12	9	0	12

Results rounded to the nearest unit

AOR MITRE

For the 100 Percent Replacement scenario, 23 sectors had their MaxIAC exceed their 1991 MAT for some period of time during the year 2000 simulated day. The results for all 23 sectors are included in this table. All other sectors were within their capacity limit for the entire day.

Other than the sectors previously summarized, several other sectors showed a noticeable load increase from the baseline to replacement scenario. Sectors ZBW024, ZBW031, ZBW047, ZDC017, and ZNY066 all showed load increases of 3 to 6 aircraft for the peak quarter-hour load and MaxIAC metrics. However, none of the 100 Percent Replacement values are extremely large in light of the fact that this comparison is between year 2000 demand and 1991 MATs, as discussed previously.

Baseline vs. 50% Replacement with Backfill (for Year 1990)

Results for All Sectors with MaxIAC > MAT

		Baseline Scenario			50% Repl. w/ Backfill		
Sector	MAT Capacity	Peak 1/4-Hour Avg.Load	Minutes w/ Load > Capacity	MaxIAC	Peak 1/4-Hour Avg.Load	Minutes w/ Load > Capacity	MaxIAC
ZDC032	15	20	60	24	20	62	23
ZNY055	12	9	2	14	11	10	16
ZNY039	12	8	0	12	10	3	14
ZDC020	16	14	3	18	14	3	18
ZDC019	15	12	1	15	12	1	16
ZNY036	12	7	0	10	10	0	13
ZOB051	17	13	0	16	13	0	17

Results rounded to the nearest unit

AOR MITRE

For the 50 Percent Replacement with Backfill scenario, seven sectors had their MaxIAC exceed their 1991 MAT for some period of time during the year 1990 simulated day. The results for all seven sectors are included in this table. All other sectors were within their capacity limit for the entire day.

Baseline vs. 50% Replacement with Backfill (for Year 2000)

Results for All Sectors with MaxIAC > MAT

Sector	MAT Capacity	Baseline Scenario: Peak 1/4-Hour Avg.Load	Baseline Scenario: Minutes w/ Load > Capacity	Baseline Scenario: MaxIAC	50% Repl. w/ Backfill: Peak 1/4-Hour Avg.Load	50% Repl. w/ Backfill: Minutes w/ Load > Capacity	50% Repl. w/ Backfill: MaxIAC
ZDC032	15	22	127	26	21	128	26
ZNY055	12	10	3	15	13	28	18
ZDC059	15	10	0	13	16	11	19
ZNY036	12	8	0	11	12	8	16
ZDC027	15	15	7	20	15	7	20
ZOB051	17	16	4	22	17	6	22
ZNY066	16	16	5	19	16	5	19
ZNY039	12	9	0	13	11	11	15
ZDC020	16	14	5	19	15	5	19
ZOB034	17	16	4	19	16	4	19
ZDC019	15	12	1	16	14	8	19
ZBW019	15	8	0	12	13	1	16
ZNY025	14	9	0	13	12	3	16
ZDC018	14	11	1	15	11	1	15
ZBW024	15	9	0	13	12	1	16
ZBW047	20	11	0	15	16	2	22
ZNY010	18	12	0	17	14	0	19
ZDC058	16	10	0	13	12	1	16
ZNY042	12	8	0	12	9	1	12
ZBW031	15	10	0	14	11	0	15

Results rounded to the nearest unit

AOR MITRE

For the 50 Percent Replacement with Backfill scenario, 20 sectors had their MaxIAC exceed their 1991 MAT for some period of time during the year 2000 simulated day. The results for all 20 sectors are included in this table. All other sectors were within their capacity limit for the entire day.

Other than the sectors previously summarized, several other sectors showed a noticeable load increase from the baseline to replacement scenario. Sectors ZBW024, ZBW047, and ZNY025 had load increases of 3 to 7 aircraft for the peak quarter-hour load and MaxIAC metrics. However, none of the 50 Percent Replacement with Backfill values are extremely large in light of the fact that this comparison is between year 2000 demand and 1991 MATs, as discussed previously.

GLOSSARY

ACES	Adaptation Controlled Environment System
AOR	Operations Research Service
APO	Office of Aviation Policy and Plans
ARD	Research and Development Service
ARTCC	Air Route Traffic Control Center
ATC	Air Traffic Control
ATP	Air Traffic Rules and Procedures Service
CAASD	Center for Advanced Aviation Systems Development
CTR	Civil Tiltrotor
CTRDAC	Civil Tiltrotor Development Advisory Committee
EPS	Engineering Performance Standards
ETMS	Enhanced Traffic Management System
FAA	Federal Aviation Administration
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
IFR	Instrument Flight Rules
MAT	Monitor Alert Threshold
MaxIAC	Maximum Instantaneous Aircraft Count
MLS	Microwave Landing System
MTR	MITRE Technical Report
NAS	National Airspace System
NASA	National Aeronautics and Space Administration
NASPAC	National Airspace System Performance Analysis Capability
OAG	Official Airline Guide
SMS	Simulation Modeling System
TAF	Terminal Area Forecast
VMC	Visual Meteorological Conditions
VNTSC	Volpe National Transportation System Center

ZBW	Boston ARTCC
ZDC	Washington ARTCC
ZID	Indianapolis ARTCC
ZJX	Jacksonville ARTCC
ZNY	New York ARTCC
ZOB	Cleveland ARTCC
ZTL	Atlanta ARTCC